Final Report

AIR QUALITY IMPACT ASSESSMENT TECHNICAL SUPPORT DOCUMENT, LITTLE SNAKE RESOURCE MANAGEMENT PLAN, MOFFAT, ROUTT AND RIO BLANCO COUNTIES, COLORADO

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TABLE OF CONTENTS

Page

1. INTRODUCTION 1-1

1.1 Project Description 1-2
1.2 Alternatives Evaluated 1-3
1.3 Study Tasks 1-3

2. EMISSIONS INVENTORY 2-1

2.1 Oil and Gas Development Alternatives 2-1

3. FAR-FIELD ANALYSES 3-1

3.1 Modeling Methodology 3-1
3.2 Modeling Scenarios 3-2
3.3 Meteorological Fields 3-3
3.4 Dispersion Model Input and Options 3-3
3.5 Post-Processing Procedures and Background Air Quality Data 3-10
3.6 Class I and Sensitive Class Ii Area Far-Field Air Quality and AQRV Impact Assessment 3-11
3.7 Cumulative Impacts Due To Little Snake RMP Alternatives 3-24

4. REFERENCES 4-1

APPENDICES

Appendix A: Construction and Natural Gas Production Emissions Inventory
Appendix B: Conventional Oil Production Emissions Inventory

TABLES

Table 2-1. Past Oil and Gas Activity and Projected Development 2-2
Table 2-2. Single-Well Production Emissions Summary for a Natural Gas Well 2-4
Table 2-3. Single-Well Production Emissions Summary for an Oil Well 2-4
Table 2-4. Maximum compressor production emissions for a single compression facility (tons/year) 2-5
Table 2-5. Drill rig population 2-5
Table 2-6. Tier 2, 3, and 4 drill rig emission factors (lb/hp-hr) 2-5
Table 2-7. Calculation of year of maximum emissions for alternative A/B/C 2-6
Table 2-8. Assumed Little Snake RMP maximum annual in-field emissions summary - construction and production 2-7
Table 3-1. CALPUFF options used in the Project's far-field Class I and II area modeling and comparison of EPA regulatory modeling default values

(Atkinson and Fox, 2006) ... 3-4
Table 3-2. Approximate distance and direction to Class I and other sensitive areas ... 3-6
Table 3-3. Distance and direction to sensitive lakes ... 3-6
Table 3-4. Number of gas, oil and non-producing wells for alternative A/B/C ... 3-8
Table 3-5. Number of gas, oil and non-producing wells for alternative D ... 3-8
Table 3-6. Average zone elevation ... 3-10
Table 3 7. Analysis background ambient air quality concentrations (µg/m3) ... 3-10
Table 3-8. Ambient standards, Class II PSD Increments, and Class I PSD Increments (µg/m3) ... 3-12
Table 3-9. CALPUFF-estimated PSD pollutant concentrations impacts for Alternatives A/B/C ... 3-14
Table 3-10. CALPUFF-estimated PSD pollutant concentrations impacts for Alternative D ... 3-15
Table 3-11. Comparison of maximum existing background concentrations (Table 3-5) plus maximum estimated impacts at any class i area due to any RMP scenario with federal and state ambient air quality standards ... 3-16
Table 3-12. Maximum nitrogen and sulfur deposition (kg/ha/yr) for five-year CALPUFF modeling for the Alternatives A/B/C ... 3-17
Table 3-13. Maximum nitrogen and sulfur deposition (kg/ha/yr) for five-year CALPUFF modeling for the Alternative D ... 3-18
Table 3-14. Lake acid neutralizing capacity (ANC) calculations for the Alternative A/B/C Scenario ... 3-20
Table 3-15. Lake acid neutralizing capacity (ANC) calculations for the Alternative D Scenario ... 3-20
Table 3-16. CALPUFF-estimated visibility impacts on Class I and II areas for the various Project Alternatives alone using Screening Method ... 3-22
Table 3-17. CALPUFF-estimated visibility impacts on Class I and II Areas for the various Project Alternatives alone using Refined Method ... 3-23

FIGURES

Figure 1-1. Little Snake RMP Area and Air Quality Analysis Domain ... 1-2
Figure 2-1. Oil and gas distribution zones in the Little Snake RMPPA. Booz Allen (2007) ... 2-2
Figure 3-1. CALPUFF-lite Domain and receptors for the draft Little Snake RMP Hypothetical Air Quality Impact Analysis ... 3-7
Figure 3-2. Map of Little Snake oil and gas development zones (shown in blue) ... 3-9

1.0 INTRODUCTION

This Air Quality Technical Support Document (AQTSD) was prepared to summarize and provide a detailed description of analyses performed to quantify hypothetical air quality impacts related to the draft Little Snake Resource Management Plan (RMP) and to demonstrate how future quantitative air pollutant dispersion modeling analysis could be performed once project-specific oil and gas developments are proposed. The methodologies used in the analysis were originally defined in an Air Quality Impact Assessment Modeling Protocol (Protocol) (Booz Allen Hamilton, 2007) with input from the lead agency, U.S. Department of Interior Bureau of Land Management (BLM), and the U.S. Environmental Protection Agency (EPA). This AQTSD discusses those methodologies as necessary and summarizes the air emission inventories and subsequent dispersion modeling analyses.

The Project's location in northwest Colorado included hypothetical air quality impacts within a defined study area (modeling domain) (Figure 1-1). The analysis area includes the BLM Little Snake Field Office as described in the draft RMP and all or a portion of the federal Class I Flat Tops, Mount Zirkel, and Eagles Nest Wilderness Areas, as well as Dinosaur National Monument. Impacts analyzed include those on air quality and air quality related values (AQRVs) resulting from assumed air emissions due to hypothetical oil and gas development activities within the RMP area as described in the draft RMP under the various analysis Alternatives. Only the far-field air quality and AQRV impacts of the hypothetical RMP emission sources are presented. Near-source ambient air quality impacts were not quantified, but should be similar to those determined for other nearby oil and gas development projects in the region (e.g., Hiawatha and Moxa Arch).

Based on an agreement with EPA Region 8, the CALPUF-lite modeling system (IWAQM, 1998; Earth Tech, 2001b; 2002) was used to assess the far-field air quality and AQRV impacts due to emissions from hypothetical oil and gas development. The CALPUFF-lite approach is meant to provide a conservative screening analysis. The chief difference between the CALPUFF-lite and refined CALPUFF modeling approaches is that CALPUFF-lite uses hourly meteorological data from a single meteorological observations site, as compared to refined CALPUFF modeling that uses hourly three-dimensional wind fields derived from CALMET.

The remainder of this Section describes the hypothetical analysis in further detail, provides a description of the alternatives evaluated, and presents a list of tasks performed during the study. Chapter 2.0 presents an overview of the emission inventories, and Chapter 3.0 describes the CALPUFF analyses performed for assessment of far-field direct impacts from the RMP. Chapter 4.0 provides references. Appendix A describes the Well Construction and Natural Gas Production Emissions Inventory, and Appendix B describes the Emission Inventory for Well Production.

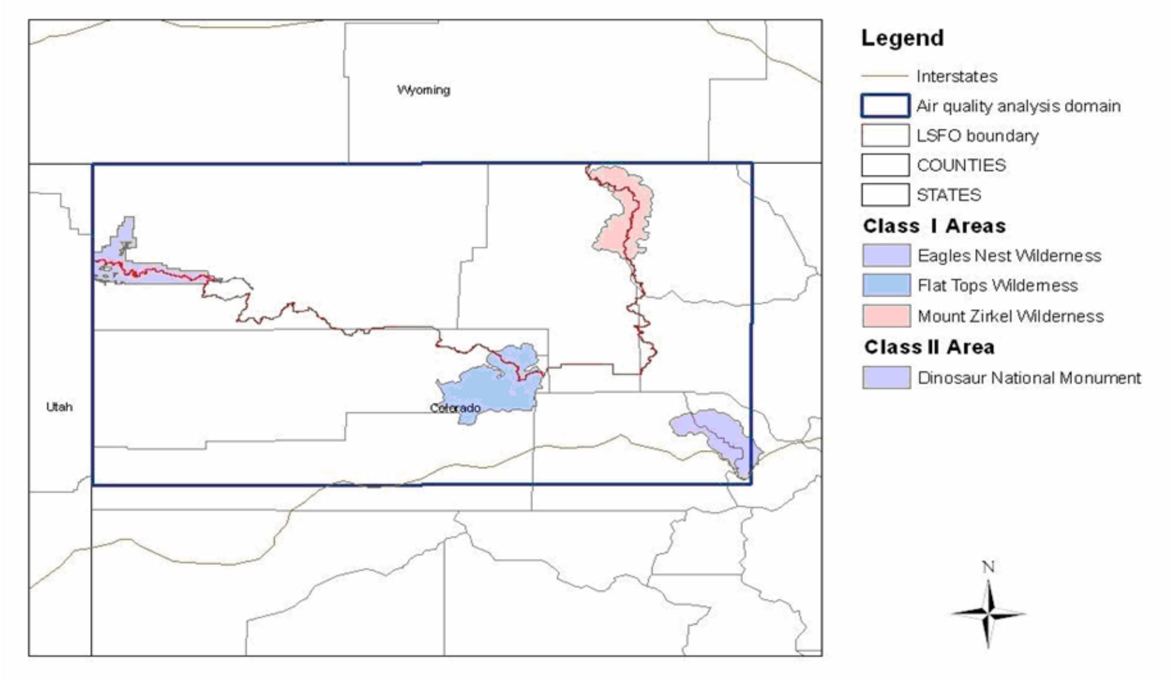

Figure 1-1. Little Snake RMP Area and Air Quality Analysis Domain.

1.1 PROJECT DESCRIPTION

The Little Snake Field Office (LSFO), Bureau of Land Management (BLM), is developing a Resource Management Plan for all the federal surface and mineral estate administered by BLM within the LSFO boundary. The Little Snake Resource Management Plan Planning Area (RMPPA) encompasses the majority of two counties in northwest Colorado – Moffat and Routt Counties – as well as a portion of northeast Rio Blanco County. The RMPPA includes approximately 1.3 million acres of BLM-administered public lands and 1.1 million acres of federally-owned mineral estate. Land ownership in the Little Snake RMPPA ranges from large tracts of BLM land to patches of public land surrounded by private and state lands. The BLM has proposed to evaluate the development of hydrocarbon resources underlying oil and gas leases owned, at least in part, by various parties within the Little Snake RMPPA in Moffat, Routt, and Rio Blanco Counties, Colorado.

1.1.1 Alternative C - Preferred Alternative

A BLM land use plan does not authorize oil and gas development, but it does identify areas that would be available for future oil and gas leasing. For analysis purposes, the Reasonable Foreseeable Development (RFD) Scenario (2005) anticipated that over the next 20 years approximately 3,031 oil and gas wells would be drilled in the Little Snake RMPPA under the Preferred Alternative (Alternative C) in addition to wells that currently exist in the RMPPA. The same number of wells also applies to the No Action Alternative (A) and Alternative B.

For all Alternatives, it is assumed that the additional wells would be drilled conventionally, i.e., with vertical well bores. All proposed wells are anticipated to be drilled during an approximate 20-year period. The average life of a well is expected to be 40 years**.**

1.2 ALTERNATIVES EVALUATED

Besides the Preferred Alternative C discussed in Section 1.1.1 above, several other alternatives are analyzed for this Project. These alternatives are summarized below. However, only two model runs were required to address all alternatives, since the well numbers proposed under only one alternative (Alternative D) differed from the Preferred Alternative (C).

1.2.1 Alternative A – No Action

Although this alternative proposes different land uses, it would have the same number of wells as the Preferred Alternative (C), and for the purposes of the air quality impacts analysis, is identical to the Preferred Alternative.

1.2.2 Alternative B

Although this alternative proposes different land uses, it would have the same number of wells as the Preferred Alternative (C), and for the purposes of the air quality impacts analysis, is identical to the Preferred Alternative.

1.2.3 Alternative D – Action With Resource Protection

An alternative with lower development than the Preferred Alternative is included in this analysis (Alternative D). For this alternative, it is anticipated that 2,273 wells for the RMP area would be developed (this scenario is 75% of the Preferred Alternative.)

1.3 STUDY TASKS

Modeling analyses were performed to quantify far-field pollutant concentrations within and nearby the RMP area from oil and gas development-related emissions sources. Modeling was conducted for the range of alternatives to ensure that the maximum potential for impacts was estimated. Impacts from both construction and production activities were calculated.

The following tasks were performed for air quality and AQRVs impact assessment:

- Air Emission Inventory.
    - Development of an air pollutant emission inventory for hypothetical oil and gas development activities assumed in the RMP area. The emission inventory, discussed in Chapter 2.0, included criteria pollutant emissions for construction activities, production activities, and ancillary facilities.

- Far-Field Direct Project Impact Analysis.
    - Assessment of far-field air quality concentration and AQRV impacts resulting from assumed oil and gas development activities in the RMP area. The far-field ambient air quality and AQRV impact assessment, discussed in Chapter 3.0, was performed to quantify the maximum predicted pollutant impacts at Class I areas and a sensitive Class II area within the study area resulting from assumed construction, drilling and production emissions.

- Far-Field Cumulative Impact Analysis.
    - Qualitative assessment of far-field air quality concentration and AQRV impacts resulting from activities proposed within the RMP area combined with other regional sources. This discussion is included in Section 3.7.

2.0 EMISSIONS INVENTORY

2.1 OIL AND GAS DEVELOPMENT ALTERNATIVES

The BLM developed a Reasonable Foreseeable Development (RFD) Scenario that estimated the potential for development of up to 3,031 oil and natural gas wells in the Little Snake RMP area over the next 20 years. The RFD Scenario of 3,031 wells drilled was assumed for Alternatives A, B, and C (Note that some of these 3,031 drilled wells would be non-productive or types other than oil or gas wells). However, due to the increase in areas closed to oil and gas leasing and open to leasing with No Surface Occupancy (NSO) stipulations proposed under Alternative D, this alternative assumed a 25 percent reduction in the number of assumed wells (or 2,273 total wells drilled) that may be developed. As with Alternatives A, B, and C, some of these 2,273 drilled wells would be non-productive or other than oil or gas wells. For both scenarios, criteria pollutant emissions were inventoried for construction activities, production activities, and ancillary facilities. Criteria pollutants included nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter less than 10 microns in diameter (PM_{10}), and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). VOC emissions were not part of the CALPUFF-lite modeling and are not discussed here.

Due to the lack of any specific project proposal (with the exception of the Hiawatha Regional Energy Development Project), EPA Region 8 agreed that BLM could combine assumed oil and gas activity into hypothetical distribution zones, based primarily on the major oil and gas formations in the planning area. This is the only possible approach where future development locations are generally unknown, and will not be known until future site-specific NEPA analyses are performed.

For the Hiawatha Regional Energy Development Project, the Operators' Proposed Action is to drill up to 4,208 new wells over the next 30 years within the Hiawatha Project Area in Wyoming and Colorado. The 4,208 well maximum represents a full development scenario based on currently known geologic and reservoir properties. The Operators estimate that approximately two-thirds (2,805) of the potential wells could be located within the Wyoming portion of the Project Area, and the remaining one-third (1,403) could be located within the Colorado portion of the Project Area that is within the boundaries of the Little Snake RMPPA. Therefore, during the 20-year life of the Little Snake RMP, 935 wells could be drilled within the draft Little Snake RMP portion of the Hiawatha project area (Booz Allen, 2007).

An estimate of well numbers per distribution zone was developed using an analysis of Applications for Permit to Drill (APDs) for the time period of January 2001 through September 2007 (Booz Allen, 2007). APDs were grouped into eleven general zones: four zones representing the major oil and gas formations/existing fields in the Little Snake RMP area (including Powder Wash, Hiawatha/Vermillion/Sugar Loaf, Great Divide East of Godiva Rim, and Sand Wash/Vermillion Basins) and seven additional zones that represent the remaining areas with high oil and gas potential. The results of the analysis of modern development trends and the projected well numbers are shown in Table 2-1.

Table 2-1. Past Oil and Gas Activity and Projected Development.

Area	Township & Range	Number of APDs 01/01/01 to 09/10/07	Percentage of APDs 01/01/01 to 09/10/07	Projected Wells – Alts A/B/C	Projected Wells – Alt D
Powder Wash	T11N – T12N R97W	21	11%	322	250
Hiawatha, Vermillion, Sugar Loaf	T11N – T12N R100W – R101W	71	37%	1,185	841
Great Divide, East of Godiva Rim	T7N – T12N R92W – R95W	55	29%	850	659
Sand Wash & Vermillion Basins	T8N – T10N R97W – R100W	22	12%	352	273
Other		21	11%	322	250
Total		190	100%	3,031	2,273

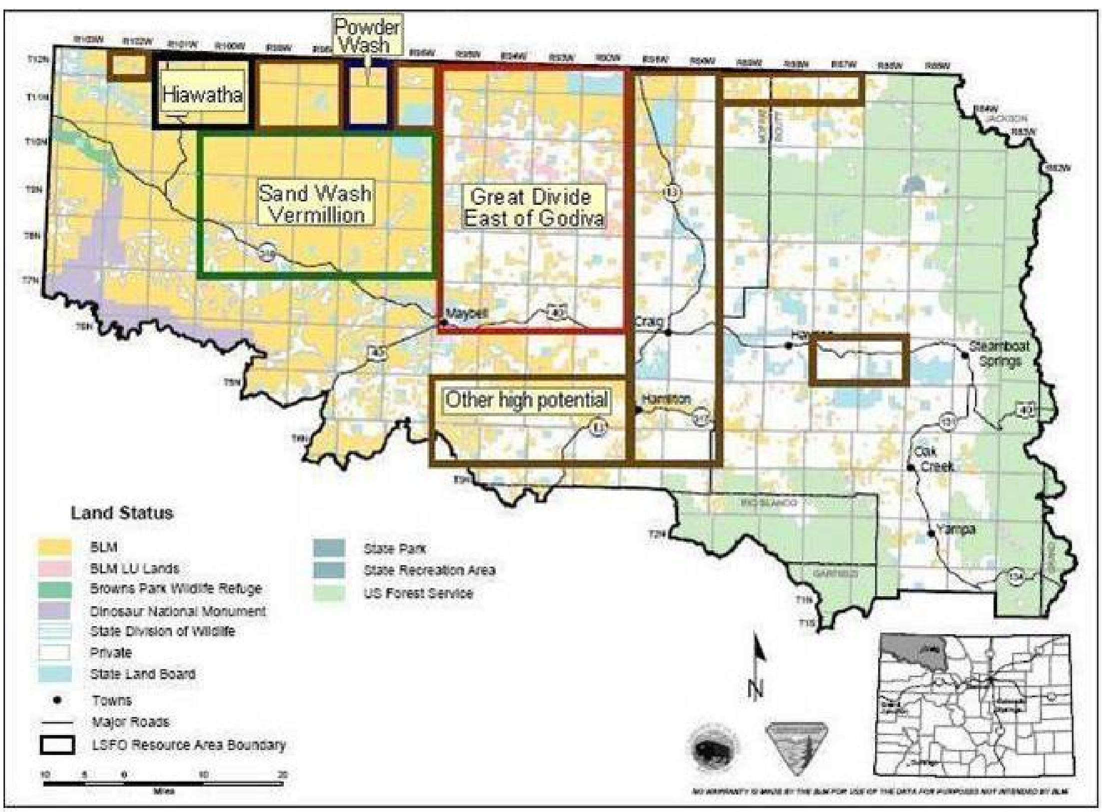

Figure 2-1. Oil and gas distribution zones in the Little Snake RMPPA. Booz Allen (2007).

2.1.1 Construction Emissions

Construction activities are a source of criteria pollutants. Construction emissions include:

- well pad and resource road construction and traffic;
- rig-move/drilling and associated traffic;
- completion/testing and associated traffic;
- pipeline installation and associated traffic; and
- wind erosion during construction activities.

Well pad and resource road emissions would include fugitive PM_{10} and $PM_{2.5}$ emissions from: (1) construction activities; and (2) traffic to and from the construction site. Other criteria pollutant emissions would occur from diesel combustion by haul trucks and heavy construction equipment. On resource roads, water would typically be used for fugitive dust control, effecting a control efficiency of 50%.

After the pad is prepared, rig-move/drilling would begin. Emissions would include fugitives from unpaved road travel to and from the drilling site and emissions from diesel drilling engines. Emissions from well completion and testing would include fugitive PM_{10} and $PM_{2.5}$ emissions from traffic and emissions from diesel haul truck tailpipes. Also, wind erosion emissions from disturbed areas would occur. During the completion phase, gas and condensate are both vented and combusted (flared) into the atmosphere. Emissions from the venting of natural gas include VOC and CO. Flaring emissions from the combustion of natural gas and condensate include $PM_{10,}$ $PM_{2.5}$, NO_x, CO, and SO_2.

Pollutant emissions would also occur from pipeline installation activities, including general construction activities, travel to and from the pipeline construction site, and diesel combustion from on-site construction equipment.

Fugitive dust (PM_{10} and $PM_{2.5}$) emissions would occur during well pad, road, and pipeline construction due to wind erosion on disturbed areas as well as vehicle traffic.

Future required emission controls were assumed to phase into operation at 20% per calendar year (for example, it is assumed that all engines will be Tier II in 2010, but only 20% of engines will be Tier IV in 2011).

The well pad design is assumed to be single-well location (i.e., one well per well pad). The estimated size of each drill pad was 2.75 acres, of which approximately 1.75 acres would be reclaimed after the well is completed and the gas gathering pipeline is installed.

A detailed description of the emissions from each of the construction activities listed above is given in Appendix A. Note that construction emissions are taken to be identical for oil and natural gas wells.

2.1.2 Production Emissions

Field production equipment and operations are a source of criteria pollutants. Pollutant emission sources during field production include:

- combustion engine emissions and dust from road travel to and from well sites;
- diesel combustion emissions from haul trucks;
- combustion emissions from well site heaters;
- condensate storage tank flashing and flashing control;
- glycol dehydrator still vent flashing;
- wind erosion from well pad disturbed areas;
- emissions from central and wellhead compressors; and
- natural gas-fired reciprocating internal combustion compressor engines.

It was assumed that each well would have a three-phase separator and glycol dehydrator to process and average of 0.50 MBtu/hour product. Condensate and water would be stored in tanks, which would be serviced weekly by a tanker truck traveling on approximately 6 miles of unsurfaced access road.

Fugitive PM_{10} and $PM_{2.5}$ emissions would occur from road travel and wind erosion from well pad disturbances. Wind erosion was assumed to occur during periods of winds greater than approximately 5.4 m s^{-1}, which are estimated to occur on 3% of modeled days. A control efficiency of 50% was assumed based on the use of watering. Criteria pollutant emissions would occur from diesel combustion in haul trucks traveling in the field during production.

Total production emissions of criteria pollutants occurring from a single natural gas or oil well are presented in Tables 2-2, and 2-3, respectively. Production emission calculations are provided in detail, in Appendix A, showing all emission factors, input parameters, and assumptions.

Table 2-2. Single-Well Production Emissions Summary for a Natural Gas Well.

Traffic Emissions[1]		Production Emissions[2]	Total Emissions
Pollutant	(tpy)	(tpy)	(tpy)
NO_x	0.18	$1.2x10^{-4}$	0.18
SO_2	0.003	$3.0x10^{-7}$	0.003
PM_{10}	0.26	$1.5x10^{-5}$	0.26
$PM_{2.5}$	0.02	$1.5x10^{-5}$	0.02

[1] Includes emissions from all traffic associated with full-field production. PM_{10} and $PM_{2.5}$ emissions.
[2] Includes emissions from indirect heater, separator heater, dehydrator heater, and dehydrator flashing

Table 2-3. Single-Well Production Emissions Summary for an Oil Well.

Traffic Emissions[1]		Production Emissions[2]	Total Emissions
Pollutant	(tpy)	(tpy)	(tpy)
NO_x	0.18	$1.3x10^{-3}$	0.18
SO_2	0.003	$4.8x10^{-4}$	0.0035
PM_{10}	0.26	$2.5x10^{-2}$	0.29
$PM_{2.5}$	0.02	$2.5x10^{-2}$	0.045

[1] Includes emissions from all traffic associated with full-field production. PM_{10} and $PM_{2.5}$ emissions.
[2] Includes emissions from indirect heater, separator heater, dehydrator heater, and dehydrator flashing

In addition, to be conservative, it was assumed that 10 central compressors (5,000 hp) would be required under Alternative A/B/C and 8 under Alternative D. In addition, thirty wellhead compressors for every 1,000 wells (200 hp) were assumed. The emissions from these two sources are shown in Table 2-4.

Table 2-4. Maximum compressor production emissions for a single compression facility (tons/year).

Pollutant	Central Compressor	Wellhead Compressor
NO_x	482.80	1.931
CO	965.61	10.57
SO_2	0.966	0.004
PM_{10}	0.573	0.128
$PM_{2.5}$	0.573	0.128

A detailed description of the emissions from natural gas production is given in Appendix A, and oil production emissions calculations are shown in Appendix B.

2.1.3 Selection of Modeled Year

In order to provide a conservative estimate of hypothetical air quality and AQRV impacts, the year of peak emissions from oil and gas development activities within the Little Snake RMP area was modeled. In determining the year of maximum combined emissions from construction and production, several assumptions were made:

1. The drilling of new wells would proceed at an even pace, with approximately 152 wells drilled each year over the life of the 20 year planning period in Alternatives A/B/C and 114 wells drilled per year for Alternative D.

2. A new central compressor station would be built every two years during the first three to four years of the project, and an additional central compressor built during the last year of the project.

3. Emissions controls on the drill rigs will be phased in over time according to the following schedule (Table 2-5) as provided by the BLM (Personal communication, 2008). Emission factors for Tier 4 that were used in the CALPUFF-lite modeling are shown in Table 2-6

Table 2-5. Drill rig population.

Year	Tier 2 and 3	Tier 4
2010	100%	0%
2011	80%	20%
2012	60%	40%
2013	40%	60%
2014	20%	80%
2015-2027	0%	100%

Table 2-6. Tier 2, 3, and 4 drill rig emission factors (lb/hp-hr).

Tier	Emission Factors					
	Unit	NO_x	PM_{10}	SO_x	CO	VOC
Tier 2	lb/hp-hr	1.52E-02	3.31E-04	5.10E-05	5.73E-03	2.20E-03
Tier 3	lb/hp-hr	1.52E-02	3.31E-04	5.10E-05	5.73E-03	2.20E-03
Tier 4	lb/hp-hr	6.61E-04	3.30E-05	5.10E-05	5.73E-03	2.20E-04

Emissions for well construction and production were calculated for the final year when Tier 4 engines would be used, as well as several years when the drill rig mix was changing during the 2011-2015 period. Drill rig emissions factors for Tiers 2, 3 and 4 in Table 2-6 were used in this calculation. Maximum NOx and total emissions occur during the final year of the project (Table 2-7). This is because production emissions increase steadily over the life of the project, and offset the effect of emissions reductions due to improved drill rig controls. The final year, 2027, was therefore chosen to be the modeled year in order to estimate the maximum potential impacts due to the RMP.

Table 2-7. Calculation of year of maximum emissions for alternative A/B/C.

Project Year	Year	Wells Drilled	Total Number of Wells	Gas Wells	Oil Wells	Number of Central Compressors	Drill Rig Tier	Emissions (tons/year)			
								SO2	NOx	PM10	All Emis
1	2008	152	152	82	30	1	100% Tier 2/3				
2	2009	152	304	164	61	1	100% Tier 2/3				
3	2010	152	456	246	91	2	100% Tier 2/3	9	987	1584	2580
4	2011	152	608	328	122	2	80% 2/3, 20% 4	16	930	1664	2610
5	2012	152	760	410	152	3	60% 2/3, 40% 4	23	840	1693	2556
6	2013	152	912	493	182	3	40% 2/3, 60% 4				
7	2014	152	1064	575	213	4	20% 2/3, 80% 4				
8	2015	152	1216	657	243	4	0% 2/3, 100% 4	10	360	1642	2012
9	2016	152	1368	739	274	5	100% Tier 4				
10	2017	152	1520	821	304	5	100% Tier 4				
11	2018	152	1672	903	334	6	100% Tier 4				
12	2019	152	1824	985	365	6	100% Tier 4				
13	2020	152	1976	1067	395	7	100% Tier 4	12	541	1703	2256
14	2021	152	2128	1149	425	7	100% Tier 4				
15	2022	152	2280	1231	456	8	100% Tier 4				
16	2023	152	2432	1313	486	8	100% Tier 4				
17	2024	152	2584	1396	517	9	100% Tier 4				
18	2025	152	2736	1478	547	9	100% Tier 4				
19	2026	152	2888	1560	577	9	100% Tier 4				
20	2027	143	3031	1637	606	10	100% Tier 4	15	1066	2044	3125

2.1.4 Total Field Emissions

Annual emissions in the RMP area under each Alternative are shown in Table 2-8. Emissions assume construction and production occurring simultaneously in the field and include one year of maximum construction emissions plus one year of production at maximum emission rates.

Construction emissions were based on well construction, drilling, drilling traffic, completion traffic, and completion flaring. Well construction emissions were based on the number of wells constructed per year and the type of well constructed. Drilling, drilling traffic, completion traffic, and completion flaring were based on the number of wells developed per year. As a conservative assumption, completion flaring operations were assumed to occur at all of the wells under construction and compression was included. Production emissions were calculated based on the total number of producing wells in the field.

Table 2-8. Assumed Little Snake RMP maximum annual in-field emissions summary - construction and production.

Alternative	Annual Development Rate per year	Pollutant	Annual Construction Emissions (tpy)	Total Producing wells	Annual Production Emissions (tpy)	Total Emissions (tpy)
Preferred Alternative A/B/C	152	PM_{10}	1543[1]	1,637	501	2,044
		$PM_{2.5}$	538[1]		70	608
		NO_x	85		982	1,066
		SO_2	8		7	15
Alternative D	114	PM_{10}	1158[1]	1,223	376	1,533
		$PM_{2.5}$	404[1]		52	456
		NO_x	63		761	825
		SO_2	6		5	11

[1] Includes wind erosion emissions.

3.0 FAR-FIELD ANALYSES

The purpose of the CALPUFF analysis was to quantify hypothetical air quality (AQ) and air quality related values (AQRVs) impacts at nearby Class I and sensitive Class II areas from assumed oil and gas activities within the RMP area due to assumed air pollutant emissions of NOx, SO_2, PM_{10}, and $PM_{2.5}$. The analyses were performed using the CALPUFF-lite modeling system. The Class I and sensitive Class II receptor areas analyzed in the far-field modeling were:

- Mount Zirkel Wilderness Area (Class I);
- Eagles Nest Wilderness Area (Class I);
- Flat Tops Wilderness Area (Class I); and
- Dinosaur National Monument (Federal Class II, Colorado area designated with the same SO_2 increment as Federal Class I).

Air pollutant concentrations predicted at these areas were compared to applicable national and state ambient air quality standards and PSD Class I increments. Also, potential impacts to AQRVs, which include visibility (regional haze) and atmospheric deposition (Sulfur and Nitrogen) were assessed. In addition, analyses were performed for seven sensitive lakes located within the Class I areas to assess potential lake acidification from acid deposition impacts. These lakes are:

- Lake Elbert in the Mount Zirkel Wilderness Area;
- Seven Lakes in the Mount Zirkel Wilderness Area;
- Lower NWL Packtrail Pothole in the Flat Tops Wilderness Area;
- Ned Wilson Lake in the Flat Tops Wilderness Area;
- Ned Wilson Spring in the Flat Tops Wilderness Area;
- Upper Ned Wilson Lake in the Flat Tops Wilderness Area;
- Trappers Lake in the Flat Tops Wilderness Area;
- Booth Lake in the Eagles Nest Wilderness Area; and
- Upper Willow Lake in the Eagles Nest Wilderness Area.

3.1 MODELING METHODOLOGY

The far-field ambient AQ and AQRV impact assessment was performed to quantify the potential maximum pollutant impacts at Class I areas and a sensitive Class II area which could result from construction, drilling and production emissions for the draft Little Snake RMP alternatives. A Modeling Protocol was prepared in coordination with BLM and EPA Region 8 prior to conducting the analyses (Booz Allen Hamilton, 2007). The procedures in the Modeling Protocol were followed in the CALPUFF-lite modeling analyses.

Because of the similarity between other oil and gas development projects and hypothetical assumptions from the draft Little Snake RMP, the near-field air quality impact assessment from the Moxa Arch and Hiawatha projects are also relevant to the draft Little Snake RMP; therefore, only the far-field AQ and AQRVs were addressed in this analysis.
Based on an agreement with EPA Region 8, the CALPUFF-lite modeling system (IWAQM, 1998; Earth Tech 2001b; 2002) was used to assess impacts, using a single SAMSON

meteorological database and discrete downwind receptors. The study was performed using the following recent and relevant guidance sources:

- *Guideline on Air Quality Models, 40 Code of Federal Regulations (C.F.R.), Part 51, Appendix W*;
- *Phase 2 of the Interagency Workgroup on Air Quality Modeling* (IWAQM, 1998);
- *Guide for Applying the EPA Class I Screening Methodology with the CALPUFF Modeling System* (Earth Tech 2001b; 2002); and
- *Federal Land Managers - Air Quality Related Values Workgroup (FLAG), Phase I Report*, December 2000 (FLAG 2000).

The CALPUFF-lite modeling approach is intended to be a conservative screening approach. The chief difference between the CALPUFF-lite and the refined CALMET/CALPUFF modeling approaches is in the meteorological inputs. The refined CALMET/CALPUFF modeling approach uses hourly three-dimensional meteorological fields to transport and disperse the CALPUFF puffs. CALPUFF-lite uses hourly meteorological data collected at a single monitoring site, similar to inputs used by the AERMOD and ISC steady-state Gaussian plume models. Since CALMET modeling is quite resource- and computer-intensive, the CALPUFF-lite approach greatly reduces the complexity and time needed to perform an analysis. CALPUFF-lite impacts were obtained for receptors located throughout the Class I areas using receptor locations developed by the USDI – National Park Service. Additional receptors were placed along the boundary and at elevated points within the Dinosaur National Monument. Although intended to be conservative, the CALPUFF-lite screening approach may not always predict maximum impacts as compared to the refined CALMET/CALPUFF modeling approach because of the complexity of three-dimensional wind fields (e.g.; recirculation of wind "puffs.").

Air pollutant emissions of NO_x, SO_2, PM_{10}, and $PM_{2.5}$ from production wells, construction, drilling and compressors for the draft RMP alternatives were modeled. A description of the emissions inventory procedures is described in Section 2 of this AQTSD with detailed inventories provided in Appendices A and B. The processing of these emissions sources for input to the CALPUFF-lite modeling system (referred to hereafter as "CALPUFF") is described in Section 3.4.4.

CALPUFF outputs were post-processed with POSTUTIL and CALPOST to estimate: (1) concentrations for comparison to ambient standards and Class I Increments; (2) wet and dry deposition amounts for comparison to sulfur (S) and nitrogen (N) deposition thresholds and to calculate potential changes in acid neutralizing capacity (ANC) for sensitive water bodies; and (3) light extinction for comparison to visibility impact thresholds in Class I and sensitive Class II areas. A discussion of the post-processing methodology used is provided in Section 3.5.

3.2 MODELING SCENARIOS

The Reasonable Foreseeable Development (RFD) Scenario (2005) anticipated that approximately 3,031 oil and gas wells would be drilled in the Little Snake RMP area under the Preferred Alternative (Alternative C) in addition to wells that currently exist. The same number of wells also applies to the No Action Alternative (A) and Alternative B. For Alternative D, there would be a 25 percent reduction in the number of assumed wells (or 2,273 total wells) that could be developed. All emissions scenarios conservatively assume that both production emissions (producing well sites and operational ancillary equipment including compressor stations) and construction emissions (drill rigs and associated traffic) occur simultaneously throughout the year. Compression was assumed to operate at 100% of fully permitted capacity. The emissions used to develop these field-wide scenarios are described in Section 2.

3.3 METEOROLOGICAL FIELDS

The meteorological data used were measured in Rock Springs, Wyoming (Rock Springs surface; Lander Hunt Field upper air) for the years 1985 and 1987-1990 as provided to EPA Region 8 personnel from the Colorado Department of Public Health and Environment Air Pollution Control Division (CDPHE-APCD). The data were processed with the CPRAMMET program.

3.4 DISPERSION MODEL INPUT AND OPTIONS

CALPUFF was run using the EPA-recommended default control file switch settings (Atkinson and Fox, 2006) for almost all parameters. Table 3-1 displays the CALPUFF options selected for the Project's modeling; deviations from EPA-recommended defaults are indicated and discussed below. Chemical transformations were modeled using the MESOPUFF II chemical mechanism for conversion of SO_2 to sulfate (SO_4) and NOx to nitric acid (HNO_3) and nitrate (NO_3). Each of these pollutant species was included in the CALPUFF model runs. Gaseous deposition of NOx, HNO_3, and SO_2 was modeled, as was particle deposition of SO_4, NO_3, $PM_{2.5}$, and PM_{10}.

3.4.1 Background Chemical Species

The Guide to CALPUFF-lite modeling recommends using monthly estimates of background ammonia and ozone concentrations for the conversion of SO_2 and NO/NO_2 to sulfates and nitrates, respectively. The CDPHE performed an analysis of background ammonia concentrations for their CALPUFF Best Available Retrofit Technology (BART) modeling for the Mount Zirkel Visibility Study, and recommended a value of 1.0 ppb for northwestern Colorado. This value was used in the CALPUFF-lite analysis. The 1.0 ppb background ammonia value is also consistent with the IWAQM guidance for forested lands (IWAQM, 1998). Monthly average ozone concentrations representative of daytime (7 a.m.-7 p.m.) periods from the Mount Zirkel Visibility Study were also used in this CALPUFF-lite analysis.

3.4.2. Deviations from EPA-Recommended Default Options

As noted in Table 3-1, several CALPUFF options deviated from EPA-recommended default settings as reported by Atkinson and Fox (2006). First, the EPA-recommended default configuration does not include any PM species, whereas this analysis included both fine $PM_{2.5}$ (PMF) and coarse PM_{10} (PMC) species. Consequently, we have 2 more emitted and modeled species than in the EPA recommendations (5 and 7 used versus 3 and 5 EPA-recommended, respectively). Finally, the EPA-recommended default value for ammonia is 10.0 ppb which, according to IWAQM (2000), is representative of grasslands. We selected a background ammonia value of 1.0 ppb based on ammonia measurements in the region from the Mt. Zirkel Visibility Study, as noted above.

Table 3-1. CALPUFF options used in the Project's far-field Class I and II area modeling and comparison of EPA regulatory modeling default values (Atkinson and Fox, 2006).

Variable	Description	EPA Default	Our Values
METDAT	CALMET input data filename	CALMET.DAT	ISC.DAT
PUFLST	Filename for general output from CALPUFF	CALPUFF.LST	CALPUFF.LST
CONDAT	Filename for output concentration data	CONC.DAT	CONC.DAT
DFDAT	Filename for output dry deposition fluxes	DFLX.DAT	DFLX.DAT
WFDAT	Filename for output wet deposition fluxes	WFLX.DAT	WFLX.DAT
VISDAT	Filename for output relative humidities (for visibility)	VISB.DAT	VISB.DAT
METRUN	Do we run all periods (1) or a subset (0)?	0	0
IBYR	Beginning year	User Defined	User Defined
IBMO	Beginning month	User Defined	User Defined
IBDY	Beginning day	User Defined	User Defined
IBHR	Beginning hour	User Defined	User Defined
IRLG	Length of runs (hours)	User Defined	User Defined
NSPEC	Number of species modeled (for MESOPUFF II chemistry)	5	7
NSE	Number of species emitted	3	7
MRESTART	Restart options (0 = no restart), allows splitting runs into smaller segments	0	2 or 3
METFM	Format of input meteorology (2 = ISC)	1	2
AVET	Averaging time lateral dispersion parameters (minutes)	60	60
MGAUSS	Near-field vertical distribution (1 = Gaussian)	1	1
MCTADJ	Terrain adjustments to plume path (3 = Plume path)	3	3
MCTSG	Do we have subgrid hills? (0 = No), allows CTDM-like treatment for subgrid scale hills	0	0
MSLUG	Near-field puff treatment (0 = No slugs)	0	0
MTRANS	Model transitional plume rise? (1 = Yes)	1	1
MTIP	Treat stack tip downwash? (1 = Yes)	1	1
MSHEAR	Treat vertical wind shear? (0 = No)	0	0
MSPLIT	Allow puffs to split? (0 = No)	0	0
MCHEM	MESOPUFF-II Chemistry? (1 = Yes)	1	1
MWET	Model wet deposition? (1 = Yes)	1	1
MDRY	Model dry deposition? (1 = Yes)	1	1
MDISP	Method for dispersion coefficients (3 = PG & MP)	3	3
MTURBVW	Turbulence characterization? (Only if MDISP = 1 or 5)	3	3
MDISP2	Backup coefficients (Only if MDISP = 1 or 5)	3	3
MROUGH	Adjust PG for surface roughness? (0 = No)	0	0
MPARTL	Model partial plume penetration? (0 = No)	1	1
MTINV	Elevated inversion strength (0 = compute from data)	0	0
MPDF	Use PDF for convective dispersion? (0 = No)	0	0
MSGTIBL	Use TIBL module? (0 = No) allows treatment of subgrid scale coastal areas	0	0
MREG	Regulatory default checks? (1 = Yes)	1	0
CSPECn	Names of species modeled (for MESOPUFF II, must be SO_2, SO_4, NOx, HNO_3, NO_3)	User Defined	SO_2, SO_4, NOx, HNO_3, NO_3, $PM_{2.5}$, PM_{10}
Specie Names	Manner species will be modeled	User Defined	SO_2, SO_4, NO_X, NO_3, HNO_3, $PM_{2.5}$, PM_{10}
Specie Groups	Grouping of species, if any.	User Defined	
NX	Number of east-west grids of input meteorology	User Defined	127
NY	Number of north-south grids of input meteorology	User Defined	50
NZ	Number of vertical layers of input meteorology	User Defined	34

Variable	Description	EPA Default	Our Values
DGRIDKM	Meteorology grid spacing (km)	User Defined	5
ZFACE	Vertical cell face heights of input meteorology	User Defined	0, 5000
XORIGKM	Southwest corner (east-west) of input meteorology	User Defined	150
YORIGIM	Southwest corner (north-south) of input meteorology	User Defined	4376
IUTMZN	UTM zone	User Defined	13
XBTZ	Base time zone of input meteorology	User Defined	7
IBCOMP	Southwest of Xindex of computational domain	User Defined	1
JBCOMP	Southwest of Y-index of computational domain	User Defined	1
IECOMP	Northeast of Xindex of computational domain	User Defined	50
JECOMP	Northeast of Y- index of computational domain	User Defined	34
LSAMP	Use gridded receptors (T -= Yes)	F	F
IBSAMP	Southwest of Xindex of receptor grid	User Defined	29
JBSAMP	Southwest of Y-index of receptor grid	User Defined	40
IESAMP	Northeast of Xindex of receptor grid	User Defined	48
JESAMP	Northeast of Y-index of receptor grid	User Defined	70
MESHDN	Gridded receptor spacing = DGRIDKM/MESHDN	1	1
ICON	Output concentrations? (1 = Yes)	1	1
IDRY	Output dry deposition flux? (1 = Yes)	1	1
IWET	Output wet deposition flux? (1 = Yes)	1	1
IVIS	Output RH for visibility calculations (1 = Yes)	1	1
LCOMPRS	Use compression option in output? (T = Yes)	T	T
ICPRT	Print concentrations? (0 = No)	0	0
IDPRT	Print dry deposition fluxes (0 = No)	0	0
IWPRT	Print wet deposition fluxes (0 = No)	0	0
ICFRQ	Concentration print interval (1 = hourly)	1	1
IDFRQ	Dry deposition flux print interval (1 = hourly)	1	1
IWFRQ	Wet deposition flux print interval (1 = hourly)	1	1
IPRTU	Print output units (1 = g/m**3; g/m**2/s)	1	1
IMESG	Status messages to screen? (1 = Yes)	1	2
Output Species	Where to output various species	User Defined	Default
LDEBUG	Turn on debug tracking? (F = No)	F	F
Dry Gas Dep	Chemical parameters of gaseous deposition species	User Defined	Default
Dry Part. Dep	Chemical parameters of particulate deposition species	User Defined	Default
RCUTR	Reference cuticle resistance (s/cm)	30.	30.
RGR	Reference ground resistance (s/cm)	10.	10.
REACTR	Reference reactivity	8	8
NINT	Number of particle-size intervals	9	9
IVEG	Vegetative state (1 = active and unstressed)	1	1
Wet Dep	Wet deposition parameters	User Defined	Default
MOZ	Ozone background? (1 = read from ozone.dat)	1	0
BCKO3	Ozone default (ppb) (Use only for missing data)	*80*	*44.7*
BCKNH3	Ammonia background (ppb)	10	1.0
RNITE1	Nighttime SO_2 loss rate (%/hr)	0.2	0.2
RNITE2	Nighttime NOx loss rate (%/hr)	2	2
RNITE3	Nighttime HNO_3 loss rate (%/hr)	2	2
SYTDEP	Horizontal size (m) to switch to time dependence	550.	550.
MHFTSZ	Use Heffter for vertical dispersion? (0 = No)	0	0
JSUP	PG Stability class above mixed layer	5	5
CONK1	Stable dispersion constant (Eq. 2.7-3)	0.01	0.01
CONK2	Neutral dispersion constant (Eq. 2.7-4)	0.1	0.1
TBD	Transition for downwash algorithms (0.5 = ISC)	0.5	0.5
IURB1	Beginning urban land use type	10	10
IURB2	Ending urban land use type	19	19

3.4.3 Model Domain and Receptors

The modeling analysis area (Figure 3-1) consisted of a 250 km by 170 km domain that includes the Little Snake RMP area, Class I and other sensitive areas. A single mixing layer was used in the vertical with the single hourly wind speed measured at the anemometer height scaled to "stack-top" as in ISC/AERMOD. The Guide to CALPUFF-lite recommends putting the top of layer 1 above the maximum expected mixing height and suggests values of 3,000 m to 5,000 m AGL (Earth Tech, 2001b; 2002). CDPHE performed an analysis to determine the maximum mixing heights in Colorado for their BART CALPUFF modeling and concluded that a 3,000 m Above Ground Level (AGL) was too low and used the mixing height maximum of 4,500 m AGL (CDPHE, 2005). Given these results, a layer 1 top (i.e., cell face 2) of 5,000 m AGL was used in this hypothetical modeling analysis.

Discrete receptors were located throughout the PSD Class I Eagles Nest, Mount Zirkel and Flat Tops wilderness areas, based on values provided by the USDA-Forest Service. Additional receptors were placed along the boundary and at elevated points within the Dinosaur National Monument. Discrete receptors were also located at sensitive lake locations identified by the USDA-Forest Service. The locations of the receptors used are shown in Figure 3-1.

Prevention of Significant Deterioration (PSD) Class I and other sensitive areas located within the modeling domain and the approximate distance of each from the Little Snake RMP area are also shown in Figure 3-1. Federal Class I areas to be evaluated are listed in Table 3-2.

Table 3-2. Approximate distance and direction to Class I and other sensitive areas.

Class I / Sensitive Areas	Distance from LSRMP	Direction from LSRMP
Eagles Nest Wilderness	30 km	Southeast
Flat Tops Wilderness	Adjacent	Southeast
Mount Zirkel Wilderness	Adjacent	East
Dinosaur National Monument	Adjacent	Southwest

In addition, discrete receptors were placed at the following sensitive lakes identified as the most sensitive to acid deposition (Table 3-3.)

Table 3-3. Distance and direction to sensitive lakes.

Sensitive Lake Receptors	Distance from LSRMP Centerpoint (km)	Direction from LSRMP Centerpoint
Lake Elbert, Mount Zirkel Wilderness	90	Northeast
Seven Lakes, Mount Zirkel Wilderness	90	Northeast
Lower NWL Packtrail Pothole, Flat Tops Wilderness	55	Southeast
Ned Wilson Lake, Flat Tops Wilderness	55	Southeast
Ned Wilson Spring #1, Flat Tops Wilderness	55	Southeast
Trappers Lake, Flat Tops Wilderness	55	Southeast
Upper Ned Wilson Lake, Flat Tops Wilderness	55	Southeast
Upper NWL Packtrail Pothole, Flat Tops Wilderness	55	Southeast
Booth Lake, Eagles Nest Wilderness	150	Southeast
Upper Willow Lake, Eagles Nest Wilderness	150	Southeast

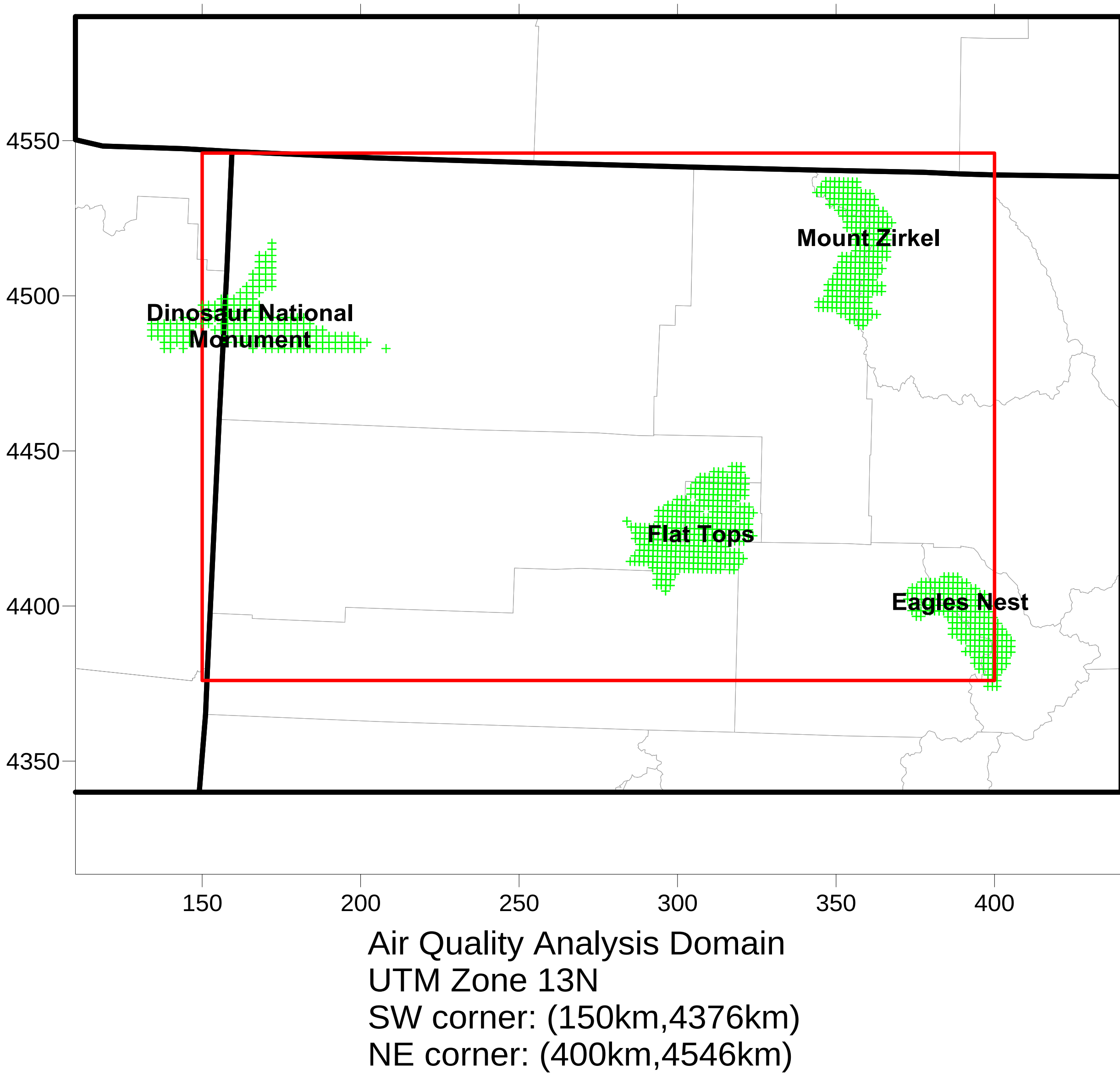

Figure 3-1. CALPUFF-lite Domain and receptors for the draft Little Snake RMP Hypothetical Air Quality Impact Analysis.

3.4.4 Emissions Processing

CALPUFF source parameters were determined for emissions from oil and gas development activities in the Little Snake Oil and Gas development zones as shown in Figure 2-1. The location of the zones within the modeling coordinate system and the receptors are shown in Figure 3-2. Location information for the original 5 zones and the 6 additional zones shown in Figures 2-1 and 3-2 were supplied by BLM (Jeremy Casterson, personal communication, 2007). Assumed RMP sources were input to CALPUFF as area sources defined by the geographic extent of these zones to idealize well operation and construction emissions. The number of natural gas, oil, and non-producing (i.e. dry holes, water wells, etc.) wells and the number of central and well head compressors expected in each of zones was specified by the BLM (Jeremy Casterson, personal communication, 2008). Tables 3-4 and 3-5 show the number of wells of each type for Alternatives A/B/C and D, respectively.

Table 3-4. Number of gas, oil and nonproducing wells for alternative A/B/C.

	Gas Wells	Oil Wells	Nonproducing Wells	Total Wells	Wellhead Compressors	Central Compressors
Sand Wash	196	73	95	364	6	1
Hiawatha	606	224	292	1122	19	4
Powder	180	67	87	334	5	1
Great Divide	475	176	229	880	14	3
Other 1	3	1	1	5	0	0
Other 2	18	7	9	34	1	0
Other 3	9	3	4	16	0	0
Other 4	35	13	17	65	1	0
Other 5	93	34	44	171	3	1
Other 6	11	4	5	20	0	0
Other 7	11	4	5	20	0	0
Total	1637	606	788	3031	49	10

Table 3-5. Number of gas, oil and nonproducing wells for alternative D.

	Gas Wells	Oil Wells	Nonproducing Wells	Total Wells	Wellhead Compressors	Central Compressors
Sand Wash	147	55	71	273	4	1
Hiawatha	454	168	218	840	13	4
Powder	135	50	65	250	4	1
Great Divide	356	132	172	660	11	2
Other 1	3	1	1	5	0	0
Other 2	13	5	6	24	1	0
Other 3	6	2	3	11	0	0
Other 4	26	10	13	49	1	0
Other 5	70	26	34	130	2	0
Other 6	8	3	4	15	0	0
Other 7	9	3	4	16	1	0
Total	1227	455	591	2273	37	8

Emissions from each zone were idealized in terms of three area sources. Each of these three area sources was defined to take up the entire geographic extent of the zone. The first of the three area sources idealizes emissions from drill rigs, and has an assumed stack height of 25 meters. The number of wells drilled in each zone during the modeled year was calculated by scaling the total number of wells drilled during a given year in the whole RMP area (152 for Alternative A/B/C, 114 for alternative D) by the fraction of the total wells that lie in that zone.

The second of the three area sources idealizes emissions from construction of new wells and production from existing wells. This source includes emissions from all sources that do not fall into the category of drill rigs or central compressor station operations, and includes wellpad construction, pipeline construction, well head compression, road traffic, well flashing and flaring, etc.; the stack height was set to 10 meters. Emissions for from production activities were calculated on a per-well basis for both oil and gas wells, as shown in Table 2-2 and Table 2-3. Then, total production emissions for both oil and gas wells in each zone were calculated by multiplying the assumed number of producing oil and gas wells in that zone by the emissions per well for each pollutant. Total construction emissions were determined by multiplying emissions for construction of a single well by the number of wells built in the modeled year in a given zone. Construction emissions include emissions from all activities involved in building the well pad and related infrastructure except drilling (i.e. construction of well pads, roads, pipelines, etc.). The number of wells built in the modeled year in each zone was calculated by scaling the total number of wells built during a given year in the whole RMP area (152) by the fraction of the total wells that lie in that zone.

The third of the three area sources idealizes emissions from central compressor stations and has an assumed stack height of 25 meters. The number of central compressor stations and well head compressors in each zone was calculated by scaling the total number of central and well head compressors in the RMP area (10 for Alternative A/B/C, 8 for Alternative D) by the fraction of the total producing natural gas wells that lie in that zone. The number of central and well head compressors in each zone for each Alternative is shown in Tables 3-4 and 3-5.

CALPUFF-lite requires that each area source be assigned an elevation. Each area source corresponding to a zone shown in Figure 3-2 was therefore assigned a mean elevation. The mean elevation was determined by laying a 4 km x 4 km mesh over the entire modeling domain, and determining an average elevation for each zone from the elevation of all of the 4 km x 4 km cells lying within each zone. This average elevation was then assigned to be the elevation of the three area sources for that zone. Average zone elevations are shown in Table 3-6.

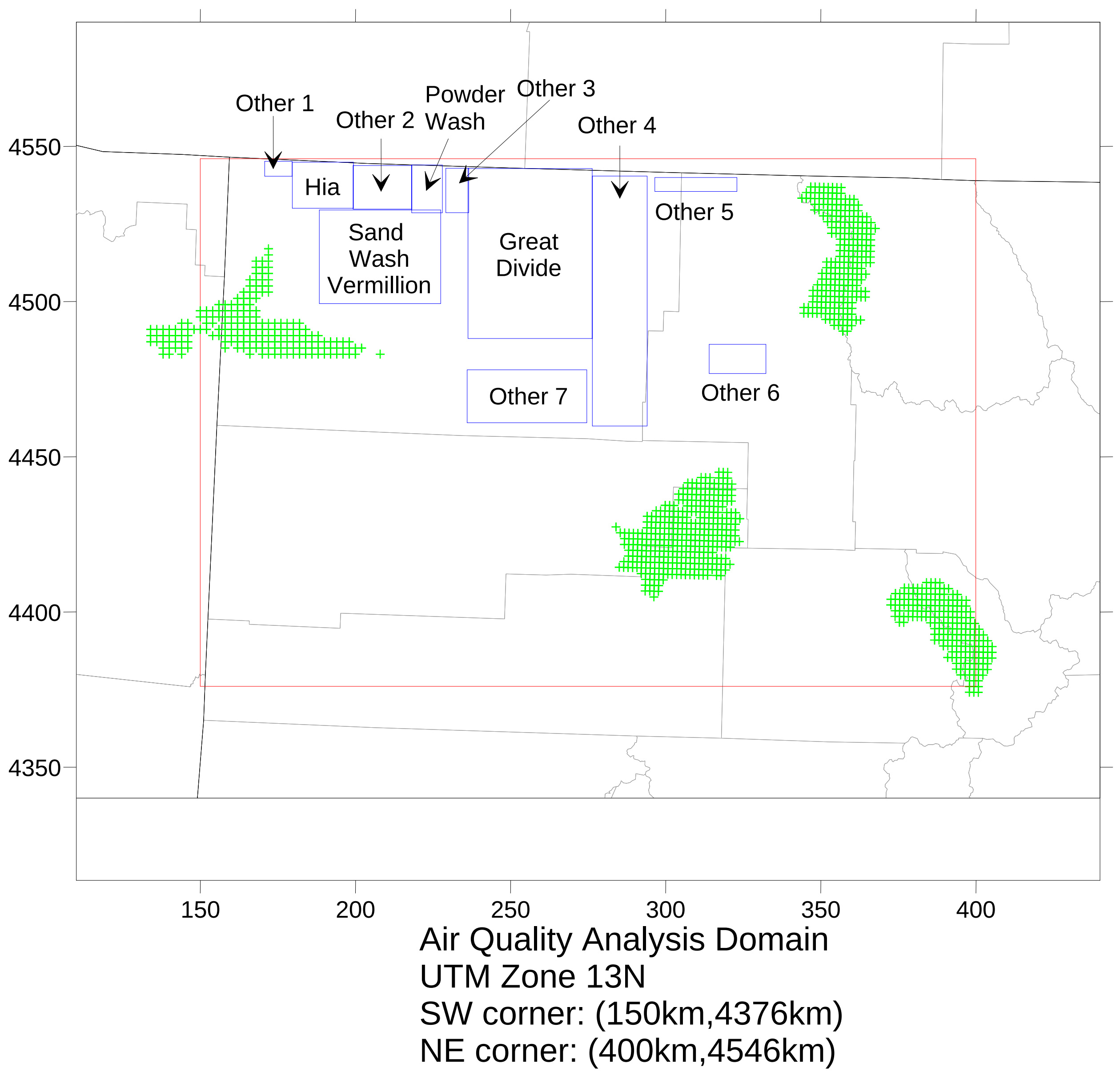

Figure 3-2. Map of Little Snake oil and gas development zones (shown in blue).

Table 3-6. Average zone elevation.

Zone	Elevation (m)
Sand Wash/Vermillion	1971
Powder Wash	2094
Hiawatha/Vermillion/ Sugar Loaf	2137
Great Divide /East of Godiva	2009
Other 1	2410
Other 2	2099
Other 3	1971
Other 4	2125
Other 5	2288
Other 6	2098
Other 7	2094

3.5 POST-PROCESSING PROCEDURES AND BACKGROUND AIR QUALITY DATA

3.5.1 Criteria Pollutants

Ambient air concentration data collected at monitoring sites in the region provide a measure of background conditions in existence during the most recent available time period (Table 3-7). Regional monitoring-based background values for criteria pollutants (PM_{10}, $PM_{2.5}$, CO, NO_x, and SO_2) were collected at monitoring sites in northwestern Colorado and Wyoming. Direct modeled pollutant concentrations were compared to PSD Class I and Class II increments. However, comparison to PSD increments is intended to indicate potential significance, and is not intended to represent a regulatory PSD Increment Consumption Analysis. Ambient air background concentrations shown in Table 3-7 were added to modeled pollutant concentrations (expressed in micrograms per cubic meter [$\mu g/m^3$]) to arrive at total ambient air quality impacts for comparison to National Ambient Air Quality Standards (NAAQS) and Colorado Ambient Air Quality Standards (CAAQS).

Table 3-7. Analysis background ambient air quality concentrations ($\mu g/m^3$).

Pollutant	Averaging Period	Measured Background Concentration
Carbon monoxide (CO)	1-hour 8-hour	2,299 1,148
Nitrogen dioxide (NO_2)	Annual	3.4
Ozone (O_3)	8-hour	68
PM_{10}	24-hour Annual	119 25
$PM_{2.5}$	24-hour Annual	20 8
Sulfur dioxide (SO_2)	3-hour 24-hour Annual	132 43 9

Source: LSRMP DEIS (BLM 2007)

3.5.2 Visibility

Potential visibility impacts were estimated by comparing predicted atmospheric extinction (derived from modeled speciated aerosols and observed daily f(RH) values) to observed data collected by the IMPROVE Program. The visibility methodology used an established approach used by BLM in previous studies. Both the Seasonal Federal Land Mangers' Air Quality Related Values Workgroup (FLAG) Screening Analysis Spreadsheet Method (Archer 2003) and the Daily FLAG Refined Analysis Spreadsheet Method (Archer 2008) were used.

The Seasonal FLAG Screening Analysis Spreadsheet was prepared based on the FLAG published method to evaluate potential visibility impacts at mandatory federal PSD Class I areas (FR 66:2, pp 382-383; Wednesday, January 3, 2001), as well as monthly f(RH) values subsequently provided by FLAG.

The Daily FLAG Refined Analysis Spreadsheet was prepared based on the FLAG published method to evaluate potential visibility impacts at mandatory federal PSD Class I areas (FR 66:2, pp 382-383; Wednesday, January 3, 2001), using available speciated aerosol measurements collected on the White River National Forest and representative measured hourly average relative humidity measurements.

3.5.3 Lake Chemistry

The most recent lake chemistry background acid neutralizing capacity (ANC) data were obtained from the USDA-Forest Service for each sensitive lake listed in Table 3-3. The 10th percentile lowest ANC values were calculated for each lake, and potential impacts were calculated following procedures provided by the USDA-Forest Service (2000).

3.6 CLASS I AND SENSITIVE CLASS II AREA FAR-FIELD AIR QUALITY AND AQRV IMPACT ASSESSMENT

For each far-field sensitive area, CALPUFF-modeled concentration impacts were post-processed with POSTUTIL and CALPOST to derive: (1) concentrations for comparison to ambient standards (CAAQS and NAAQS) and PSD Increments; (2) deposition rates for comparison to sulfur (S) and nitrogen (N) deposition thresholds and to calculate changes to ANC at sensitive lakes; and (3) light extinction changes for comparison to visibility impact thresholds.

3.6.1 Far-Field Concentration Impacts

Under federal and state PSD regulations, increases in ambient air concentrations in Class I and II areas are limited by PSD Increments. Specifically, emissions associated with a particular development may increase ambient concentrations above baseline levels only within those specific increments developed for SO_2, PM_{10}, and NO_2.

Modeled concentrations predicted in Federal PSD Class I and II areas for all alternatives were compared to appropriate PSD Increments. These demonstrations are for informational purposes only and are not regulatory PSD Increment consumption analyses, which would be completed, as necessary, during CDPHE-APCD permitting processes.

The CALPOST and POSTUTIL post-processors were used to summarize potential concentration impacts of NO_2, SO_2, PMF, and PMC, and were compared to applicable ambient air quality standards, PSD Class I and Class II increments, and significance levels. Table 3-8 lists the ambient standards and PSD Class I increments to which the potential concentration impacts were compared.

PM_{10} concentrations were computed by adding predicted CALPUFF concentrations of PMF, PMC, SO_4, and NO_3, whereas $PM_{2.5}$ concentrations were calculated as the sum of modeled PMF, SO_4, and NO_3 concentrations.

Table 3-8. Ambient standards, Class II PSD Increments, and Class I PSD Increments (µg/m³).

Pollutant/Averaging Time	Ambient Air Quality Standards		PSD Class II Increment	PSD Class I Increment
	National	Colorado		
Carbon monoxide (CO)				
1-hour [1]	40,000	40,000	--	--
8-hour [1]	10,000	10,000	--	--
Nitrogen dioxide (NO_2)				
Annual [2]	100	100	25	2.5
Ozone (O_3)				
8-hour [3]	157	157	--	--
PM_{10}				
24-hour [1]	150	150	30	8
Annual	--	--	17	4
$PM_{2.5}$				
24-hour	35	--	--	--
Annual [2]	15	--	--	--
Sulfur dioxide (SO_2)				
3-hour [1]	1,300	700 [4]	512	25
24-hour [1]	365	100 [4]	91	5
Annual [2]	80	15 [4]	20	2

1 No more than one exceedance per year.
2 Annual arithmetic mean.
3 Average of annual fourth-highest daily maximum 8-hour average.
4 Colorado Ambient Air Quality Standards are more stringent than the Federal standards .
Note: On September 21, 2006, EPA announced final revisions to the National Ambient Air Quality Standards for particulate matter. The revision strengthens the 24-hour $PM_{2.5}$ standard from 65 to 35 ug/m³ and revokes the annual PM_{10} standard of 50 ug/m³. EPA retained the existing annual $PM_{2.5}$ standard of 15 ug/m³ and the 24-hour PM_{10} standard of 150 ug/m³.

3.6.1.1 Far-Field Concentration Results

The maximum predicted concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ at any receptor within each of the PSD Class I and Class II areas for all modeled alternatives are shown in Tables 3-9 and 3-10. Table 3-9 displays the maximum direct pollutant concentrations at Class I and Class II areas due to Alternatives A/B/C and compares them to the PSD increments. The highest potential estimated impacts due to assumed oil and gas activities in the RMP area occur in Dinosaur National Monument whose impacts are:

- Less than 1% of the PSD Class I increments for annual, 24-hour and 3-hour SO_2 concentrations;
- Less than 4% and 15% of the PSD Class I area increments for annual and 24-hour PM_{10}, respectively; and
- Less than 2% of the PSD Class I area increment for annual NO_2

Table 3-10 displays the maximum estimated potential direct pollutant concentrations due to Alternative D and compares them to the PSD increments. As in Alternatives A/B/C, the highest potential estimated impacts due to assumed oil and gas activities in the RMP area occur in Dinosaur National Monument whose impacts are:

- Less than 1% of the PSD Class I increments for annual, 24-hour and 3-hour SO_2 concentrations;
- Less than 3% and 11% of the PSD Class I area increments for annual and 24-hour PM_{10}, respectively; and
- Less than 2% of the PSD Class I area increment for annual NO_2.

The PSD Class I SO_2 increments are applicable in Dinosaur National Monument under Colorado law, but less stringent Class II NO_2 and SO_2 federal increments apply within Dinosaur National Monument.

Tables 3-9 and 3-10 show that the estimated potential air quality impacts due to any of the draft Little Snake RMP alternatives would not exceed any PSD Class I area increment at any Class I or Class II area. For areas and all pollutants, Alternatives A/B/C have larger impacts than Alternative D.

The CALPUFF-estimated potential maximum concentration increments due to any Project alternative with the cumulative emissions at any Class I or sensitive Class II area were combined with the existing maximum background concentrations (see Table 3-8) in the region to obtain a total estimated concentration that is compared against the NAAQS and CAAQS in Table 3-11. The maximum CALPUFF-estimated potential impacts due to any alternative occur at the Dinosaur National Monument Class II Area. Table 3-11 shows compliance with all State and federal ambient air quality standards when the maximum RMP impacts are added to the maximum background concentrations to obtain a total predicted concentration.

In summary, the modeling results indicate that, for the Alternative A/B/C and Alternative D scenarios, impacts would not exceed any air quality standards (CAAQS and NAAQS) or PSD increments (The PSD demonstrations are for informational purposes only and do not constitute a regulatory PSD increment consumption analysis).

Table 3-9. CALPUFF-estimated PSD pollutant concentrations impacts for Alternatives A/B/C.

Species and Averaging Time	PSD Class I Area Increment (µg/m^3)	Concentration Estimates (µg/m^3)			
		DINO	EANE	FLAT	MOZI
1985					
SO_2 Annual	2.00	0.0007	0.0000	0.0001	0.0006
SO_2 24-Hour*	5.00	0.0090	0.0004	0.0011	0.0040
SO_2 3-Hour*	25.00	0.0240	0.0010	0.0037	0.0094
PM_{10} Annual	4.00	0.0958	0.0020	0.0096	0.0723
PM_{10} 24-Hour*	8.00	1.1395	0.0578	0.1713	0.4162
NO_2 Annual	2.50	0.0275	0.0001	0.0011	0.0229
1987					
SO_2 Annual	2.00	0.0009	0.0000	0.0001	0.0005
SO_2 24-Hour*	5.00	0.0062	0.0002	0.0008	0.0038
SO_2 3-Hour*	25.00	0.0180	0.0009	0.0028	0.0069
PM_{10} Annual	4.00	0.1275	0.0014	0.0083	0.0658
PM_{10} 24-Hour*	8.00	0.8661	0.0318	0.1001	0.3612
NO_2 Annual	2.50	0.0373	0.0001	0.0009	0.0197
1988					
SO_2 Annual	2.00	0.0006	0.0000	0.0001	0.0005
SO_2 24-Hour*	5.00	0.0046	0.0004	0.0009	0.0017
SO_2 3-Hour*	25.00	0.0168	0.0018	0.0029	0.0047
PM_{10} Annual	4.00	0.0816	0.0013	0.0067	0.0635
PM_{10} 24-Hour*	8.00	0.6606	0.0421	0.0954	0.2160
NO_2 Annual	2.50	0.0245	0.0001	0.0009	0.0188
1989					
SO_2 Annual	2.00	0.0006	0.0000	0.0000	0.0004
SO_2 24-Hour*	5.00	0.0041	0.0002	0.0006	0.0028
SO_2 3-Hour*	25.00	0.0127	0.0005	0.0019	0.0073
PM_{10} Annual	4.00	0.0925	0.0007	0.0047	0.0535
PM_{10} 24-Hour*	8.00	0.6238	0.0212	0.0871	0.2679
NO_2 Annual	2.50	0.0278	0.0000	0.0005	0.0156
1990					
SO_2 Annual	2.00	0.0007	0.0000	0.0001	0.0003
SO_2 24-Hour*	5.00	0.0053	0.0003	0.0008	0.0016
SO_2 3-Hour*	25.00	0.0160	0.0011	0.0025	0.0057
PM_{10} Annual	4.00	0.1065	0.0011	0.0071	0.0482
PM_{10} 24-Hour*	8.00	0.8147	0.0290	0.0872	0.2589
NO_2 Annual	2.50	0.0331	0.0001	0.0010	0.0137

*Highest second high at any receptor in the Class I area.

Table 3-10. CALPUFF-estimated PSD pollutant concentrations impacts for Alternative D.

Species and Averaging Time	PSD Class I Area Increment ($\mu g/m^3$)	Concentration Estimates ($\mu g/m^3$)			
		DINO	EANE	FLAT	MOZI
1985					
SO_2 Annual	2.00	0.0005	0.0000	0.0001	0.0004
SO_2 24-Hour*	5.00	0.0069	0.0003	0.0008	0.0029
SO_2 3-Hour*	25.00	0.0182	0.0008	0.0028	0.0067
PM_{10} Annual	4.00	0.0727	0.0015	0.0074	0.0522
PM_{10} 24-Hour*	8.00	0.8736	0.0441	0.1285	0.2963
NO_2 Annual	2.50	0.0229	0.0001	0.0009	0.0125
1987					
SO_2 Annual	2.00	0.0007	0.0000	0.0000	0.0004
SO_2 24-Hour*	5.00	0.0047	0.0002	0.0006	0.0027
SO_2 3-Hour*	25.00	0.0138	0.0007	0.0022	0.0048
PM_{10} Annual	4.00	0.0966	0.0011	0.0064	0.0477
PM_{10} 24-Hour*	8.00	0.6536	0.0244	0.0758	0.2568
NO_2 Annual	2.50	0.0307	0.0001	0.0007	0.0107
1988					
SO_2 Annual	2.00	0.0004	0.0000	0.0000	0.0003
SO_2 24-Hour*	5.00	0.0035	0.0003	0.0007	0.0012
SO_2 3-Hour*	25.00	0.0128	0.0014	0.0022	0.0035
PM_{10} Annual	4.00	0.0619	0.0010	0.0052	0.0462
PM_{10} 24-Hour*	8.00	0.4996	0.0321	0.0724	0.1582
NO_2 Annual	2.50	0.0203	0.0001	0.0007	0.0103
1989					
SO_2 Annual	2.00	0.0005	0.0000	0.0000	0.0003
SO_2 24-Hour*	5.00	0.0031	0.0001	0.0005	0.0020
SO_2 3-Hour*	25.00	0.0097	0.0004	0.0014	0.0052
PM_{10} Annual	4.00	0.0701	0.0006	0.0036	0.0389
PM_{10} 24-Hour*	8.00	0.4730	0.0159	0.0663	0.1986
NO_2 Annual	2.50	0.0231	0.0000	0.0004	0.0087
1990					
SO_2 Annual	2.00	0.0005	0.0000	0.0000	0.0003
SO_2 24-Hour*	5.00	0.0041	0.0003	0.0006	0.0012
SO_2 3-Hour*	25.00	0.0122	0.0008	0.0018	0.0038
PM_{10} Annual	4.00	0.0805	0.0009	0.0055	0.0350
PM_{10} 24-Hour*	8.00	0.6209	0.0226	0.0658	0.1889
NO_2 Annual	2.50	0.0276	0.0001	0.0007	0.0074

*Highest second high at any receptor in the Class I area.

Table 3-11. Comparison of maximum existing background concentrations (Table 3-5) plus maximum estimated impacts at any class i area due to any RMP scenario with federal and state ambient air quality standards.

Pollutant / Averaging Time	Ambient Air Quality Standards ($\mu g/m^3$)				Estimated Impact ($\mu g/m^3$)
	National	Colorado	Total	Background[1]	Increment[2]
NO_2					
Annual	100	100	**3.4**	3.4	0.037
PM_{10}					
24-hour	150	150	**120**	119	1.140
Annual	--	--	**25**	25	0.127
$PM_{2.5}$					
24-hour	35	--	**21**	20	1.105
Annual	15	--	**8**	8	0.124
SO_2					
3-hour	1,300	700	**132**	132	0.024
24-hour	365	100	**43**	43	0.009
Annual	80	15	**9.0**	9	0.001

1 Maximum current background concentration in the region (Table 3-5)
2 Maximum Cumulative Emissions Plus Project increment concentration at any Class I or Class II area for any of the modeling years

3.6.2 Sulfur and Nitrogen Deposition

Maximum predicted total sulfur (S) and nitrogen (N) deposition impacts were estimated for each of the RMP alternatives. The POSTUTIL utility was used to estimate total S and N fluxes from CALPUFF predicted wet and dry fluxes of SO_2, SO_4, NO_x, NO_3, and HNO_3. The N associated with ammonium (NH_4) is assumed to be bound to SO_4 and NO_3 was also included in the N deposition. CALPOST was then used to summarize the annual S and N deposition values from the POSTUTIL program. The maximum calculated total annual S and N deposition at any receptor in each Class I and Class II area was reported. Total deposition impacts from the RMP alternatives and background values were compared to USDA-Forest Service levels of concern, defined as 5 kg/ha-yr for S and 3 kg/ha-yr for N (Fox et al. 1989). It is understood that the USDA-Forest Service Region 2 no longer considers these levels protective; however, in the absence of alternative peer-reviewed values, comparisons with these national values were made. The maximum predicted total annual N and S deposition impacts at Class I and sensitive Class II areas for the different alternatives are given in Tables 3-12 and 3-13. Modeling results for Alternatives A/B/C and Alternative D indicate there were no significant direct Project total N or S deposition impacts. The maximum nitrogen deposition impacts are more than a factor of 100 lower than the 3.0 kg/ha/yr level of concern. Impacts from Alternative D were lower than for Alternative A/B/C for all areas.

Table 3-12. Maximum nitrogen and sulfur deposition (kg/ha/yr) for five-year CALPUFF modeling for the Alternatives A/B/C.

Total Deposition	N	S
FS Threshold	3.000	5.000
Dinosaur NM		
1985	0.0057	0.0002
1987	0.0080	0.0003
1988	0.0056	0.0002
1989	0.0069	0.0003
1990	0.0070	0.0002
Eagles Nest		
1985	0.0001	0.0000
1987	0.0001	0.0000
1988	0.0001	0.0000
1989	0.0000	0.0000
1990	0.0001	0.0000
Flat Top		
1985	0.0004	0.0000
1987	0.0005	0.0000
1988	0.0004	0.0000
1989	0.0002	0.0000
1990	0.0005	0.0000
Mount Zirkel		
1985	0.0059	0.0002
1987	0.0052	0.0002
1988	0.0051	0.0002
1989	0.0041	0.0001
1990	0.0039	0.0001

annual average at max receptor

Table 3-13. Maximum nitrogen and sulfur deposition (kg/ha/yr) for five-year CALPUFF modeling for the Alternative D.

Total Deposition	N	S
FS Threshold	**3.000**	**5.000**
Dinosaur NM		
1985	0.0047	0.0002
1987	0.0066	0.0002
1988	0.0046	0.0002
1989	0.0057	0.0002
1990	0.0058	0.0002
Eagles Nest		
1985	0.0001	0.0000
1987	0.0001	0.0000
1988	0.0001	0.0000
1989	0.0000	0.0000
1990	0.0001	0.0000
Flat Top		
1985	0.0003	0.0000
1987	0.0004	0.0000
1988	0.0003	0.0000
1989	0.0002	0.0000
1990	0.0004	0.0000
Mount Zirkel		
1985	0.0034	0.0002
1987	0.0029	0.0001
1988	0.0029	0.0001
1989	0.0023	0.0001
1990	0.0022	0.0001

annual average at max receptor

3.6.3 Acid Neutralizing Capacity Calculations for Sensitive Lakes

The CALPUFF-lite predicted annual deposition fluxes of S and N at sensitive lake receptors listed in Section 3.2.3 were used to estimate the potential change in sensitive lake ANC. The change in ANC were calculated following the January 2000, USDA-Forest Service Rocky Mountain Region's *Screening Methodology for Calculating ANC Change to High Elevation Lakes, User's Guide* (USDA-Forest Service 2000). The predicted changes in ANC were compared with the Level of Acceptable Change (LAC) thresholds of 10% for lakes with existing ANC values greater than 25 microequivalents per liter (μeq/l) and 1 μeq/l for lakes with background ANC values of 25 μeq/l and less. Of the lakes in the study area identified by the USDA Forest Service as acid sensitive, only Upper Ned Wilson Lake is considered very acid sensitive as it has an ANC value of less than 25 μeq/l (12.7 μeq/l; see Table 3-14).

ANC calculations were performed for each of the RMP alternatives, with the results presented in Tables 3-14 and 3-15. For the sensitive lakes that have background ANC above 25 μeq/l, the maximum change in ANC was 0.08%. Therefore, assumed deposition impacts from direct oil and gas development emissions would not contribute significantly to an increase in acidification at any of the sensitive lakes with background ANC > 25 μeq/l. The estimated change at Upper Ned Wilson Lake was 0.002 μeq/l for both the Alternative A/B/C and Alternative D scenarios. Thus, neither Alternatives A/B/C nor Alternative D is estimated to have an adverse impact on lake acidity at any lake in the region.

Table 3-14. Lake acid neutralizing capacity (ANC) calculations for the Alternative A/B/C Scenario.

	Background (ueq/l)	Tot S Dep (kg/ha-yr)	Tot N Dep (kg/ha-yr)	ppt (m)	Delta ANC (percent)	Delta ANC (ueq/l)	East UTM 13	North UTM 13	Elevation (meters)	Longitude NAD27	Latitude NAD27	Elevation feet
BOOTH LAKE	85.8	3.0E-06	4.6E-05	0.9	0.0007	n/a	388113	4394910	3501	106.3050	39.6986	11485
UPPER WILLOW LAKE	132.8	2.0E-06	3.1E-05	0.7	0.0004	n/a	399208	4388895	3469	106.1747	39.6458	11380
LOWER NWL PACKTRAIL POTHOLE	29.6	1.4E-05	2.4E-04	1.1	0.0083	n/a	301574	4426586	3383	107.3233	39.9681	11100
NED WILSON LAKE	39.6	1.3E-05	2.3E-04	1.1	0.0059	n/a	301532	4425909	3383	107.3239	39.9614	11100
NED WILSON SPRING	740.6	1.3E-05	2.3E-04	1.1	0.0003	n/a	301450	4425479	3365	107.3244	39.9581	11040
TRAPPERS LAKE	661.2	1.4E-05	2.4E-04	0.9	0.0005	n/a	309555	4428635	2934	107.2305	39.9883	9627
UPPER NED WILSON LAKE	12.7	1.4E-05	2.4E-04	1.1	0.0193	0.002	301535	4426001	3389	107.3236	39.9628	11120
UPPER NWL PACKTRAIL POTHOLE	47.9	1.4E-05	2.4E-04	1.1	0.0051	n/a	301590	4426308	3383	107.3231	39.9656	11100
LAKE ELBERT	60.2	9.5E-05	1.9E-03	1.4	0.0252	n/a	355649	4499340	3286	106.7069	40.6342	10780
SEVEN LAKES	36.2	1.2E-04	3.0E-03	1.2	0.0768	n/a	358320	4528340	3271	106.6819	40.8958	10733
	Lowest 10th Percentile				**10 percent threshold**	**1 ueq/l threshold**						

Table 3-15. Lake acid neutralizing capacity (ANC) calculations for the Alternative D Scenario.

	Background (ueq/l)	Tot S Dep (kg/ha-yr)	Tot N Dep (kg/ha-yr)	ppt (m)	Delta ANC (percent)	Delta ANC (ueq/l)	East UTM 13	North UTM 13	Elevation (meters)	Longitude NAD27	Latitude NAD27	Elevation feet
BOOTH LAKE	85.8	2.2E-06	3.5E-05	0.9	0.0005	n/a	388113	4394910	3501	106.3050	39.6986	11485
UPPER WILLOW LAKE	132.8	1.5E-06	2.3E-05	0.7	0.0003	n/a	399208	4388895	3469	106.1747	39.6458	11380
LOWER NWL PACKTRAIL POTHOLE	29.6	1.1E-05	1.9E-04	1.1	0.0064	n/a	301574	4426586	3383	107.3233	39.9681	11100
NED WILSON LAKE	39.6	1.0E-05	1.8E-04	1.1	0.0045	n/a	301532	4425909	3383	107.3239	39.9614	11100
NED WILSON SPRING	740.6	1.0E-05	1.8E-04	1.1	0.0002	n/a	301450	4425479	3365	107.3244	39.9581	11040
TRAPPERS LAKE	661.2	1.1E-05	1.9E-04	0.9	0.0004	n/a	309555	4428635	2934	107.2305	39.9883	9627
UPPER NED WILSON LAKE	12.7	1.1E-05	1.9E-04	1.1	0.0149	0.002	301535	4426001	3389	107.3236	39.9628	11120
UPPER NWL PACKTRAIL POTHOLE	47.9	1.1E-05	1.9E-04	1.1	0.0040	n/a	301590	4426308	3383	107.3231	39.9656	11100
LAKE ELBERT	60.2	7.2E-05	1.4E-03	1.4	0.0182	n/a	355649	4499340	3286	106.7069	40.6342	10780
SEVEN LAKES	36.2	9.1E-05	1.9E-03	1.2	0.0490	n/a	358320	4528340	3271	106.6819	40.8958	10733
	Lowest 10th Percentile				**10 percent threshold**	**1 ueq/l threshold**						

3.6.4 Visibility

The hypothetical CALPUFF-lite model-predicted concentration impacts at far-field PSD Class I and sensitive Class II receptors were post-processed with CALPOST to estimate potential impacts to visibility (regional haze) for each analyzed alternative and cumulative sources for comparison to visibility impact thresholds. CALPOST estimated visibility impacts from predicted concentrations of PMC, PMF, SO_4, and NO_3 using the original IMPROVE reconstructed mass extinction equation (Malm et al., 2000) as recommended by FLAG (2000) and EPA (2003a, b).

Change in atmospheric light extinction relative to background conditions is used to measure regional haze. Analysis thresholds for atmospheric light extinction are set forth in FLAG (2000) report results as a percent change in light extinction over natural background conditions. The thresholds of concern are defined as 5% from a single emission source and 10% from multiple sources changes over the measured reference background condition. Potential visibility impacts are also expressed as a change in deciviews (dv) over natural background where 1.0 dv represents a "just noticeable change," numerically equal to a 10% change in extinction over natural background. The BLM uses a 1.0 dv "just noticeable change" as a significance threshold; however, there are no applicable local, state, tribal, or federal regulatory visibility standards. Other federal agencies use a 0.5 dv change as a screening threshold for significance. The USDA-Forest Service and USDI – National Park Service compare direct project impacts to the 0.5 dv level, and those comparisons are included in this document. Lastly, the reader should be aware that Class II areas are not subject to the National Visibility Goal of no manmade impairment of visibility within federal mandatory Class I areas.

3.6.4.1 Visibility Impacts due to Little Snake RMPPA Alternatives

Table 3-16 shows the CALPUFF-estimated visibility impacts at the Class I and sensitive II areas due to Alternatives A/B/C using the screening method described above. Alternatives A/B/C are estimated to have a potentially significant adverse impact at Mount Zirkel Wilderness Area and Dinosaur National Monument but not at the Eagles Nest and Flat Tops Wilderness Areas. The largest potential visibility impacts are estimated to occur at the Dinosaur National Monument Class II Area, with Alternatives A/B/C exceeding the 1.0 dv threshold on zero to 5 days out of the 5-year period, or up to 1.4% of modeled days. Impacts at the Mount Zirkel Class I Area were slightly smaller, with zero to 4 days exceeding the 1.0 dv threshold, or up to 1.1% of modeled days. Impacts for Alternative D were smaller than those for Alternatives A/B/C. At Dinosaur National Monument, the 1.0 dv threshold was exceeded on zero to 2 (0.5%) of modeled days; no days were predicted to exceed a 1.0 dv "just noticeable change" at Mount Zirkel Class I Area..

The results of the refined visibility analysis are shown in Table 3-17. No days were predicted to exceed a 1.0 dv "just noticeable change" at either the Flat Tops or Eagles Nest Class I areas. Under Alternative A/B/C, the 1.0 dv threshold was exceeded at Dinosaur Class II area on zero to 5 days (1.4%), and zero to 2 days (0.5%) at the Mount Zirkel Class I area. For Alternative D, zero to 3 days (0.8%) were predicted to exceed 1.0 dv at Dinosaur Class II area, and zero to one day (0.3%) at the Mount Zirkel Class I Area.

Table 3-16. CALPUFF-estimated visibility impacts on Class I and II areas for the various Project Alternatives alone using Screening Method.

		alt_abc					alt_d				
		1985	**1987**	**1988**	**1989**	**1990**	**1985**	**1987**	**1988**	**1989**	**1990**
Flat Tops Wilderness	Number of days at or above 0.5 dv	0	1	0	0	0	0	0	0	0	0
	Number of days at or above 1.0 dv	0	0	0	0	0	0	0	0	0	0
Mount Zirkel Wilderness	Number of days at or above 0.5 dv	11	9	0	2	1	6	4	0	1	0
	Number of days at or above 1.0 dv	4	1	0	1	0	0	0	0	0	0
Eagles Nest Wilderness	Number of days at or above 0.5 dv	0	0	0	0	0	0	0	0	0	0
	Number of days at or above 1.0 dv	0	0	0	0	0	0	0	0	0	0
Dinosaur NM	Number of days at or above 0.5 dv	7	17	9	5	8	6	13	5	3	6
	Number of days at or above 1.0 dv	3	5	1	0	2	2	2	0	0	2

Table 3-17. CALPUFF-estimated visibility impacts on Class I and II Areas for the various Project Alternatives alone using Refined Method.

Flat Tops Wilderness Area (White River National Forest)		1985		1987		1988		1989		1990	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
alt_abc	Number of days at or above 0.5 dv	0	1	0	1	0	0	0	0	0	0
	Number of days at or above 1.0 dv	0	0	0	0	0	0	0	0	0	0
alt_d	Number of days at or above 0.5 dv	0	0	0	1	0	0	0	0	0	0
	Number of days at or above 1.0 dv	0	0	0	0	0	0	0	0	0	0
Mount Zirkel Wilderness Area											
		1985		1987		1988		1989		1990	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
alt_abc	Number of days at or above 0.5 dv	3	10	2	8	0	2	1	3	0	1
	Number of days at or above 1.0 dv	0	2	0	2	0	0	0	2	0	0
alt_d	Number of days at or above 0.5 dv	0	5	1	4	0	0	0	2	0	0
	Number of days at or above 1.0 dv	0	1	0	1	0	0	0	0	0	0
Eagles Nest Wilderness Area (White River National Forest)											
		1985		1987		1988		1989		1990	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
alt_abc	Number of days at or above 0.5 dv	0	0	0	0	0	0	0	0	0	0
	Number of days at or above 1.0 dv	0	0	0	0	0	0	0	0	0	0
alt_d	Number of days at or above 0.5 dv	0	0	0	0	0	0	0	0	0	0
	Number of days at or above 1.0 dv	0	0	0	0	0	0	0	0	0	0
Dinosaur National Monument (White River National Forest)											
		1985		1987		1988		1989		1990	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
alt_abc	Number of days at or above 0.5 dv	6	11	10	24	5	15	3	9	4	12
	Number of days at or above 1.0 dv	2	4	1	5	0	2	0	1	0	2
alt_d	Number of days at or above 0.5 dv	5	7	8	15	1	12	1	3	2	7
	Number of days at or above 1.0 dv	1	3	0	3	0	1	0	0	0	2

3.7 CUMULATIVE IMPACTS DUE TO LITTLE SNAKE RMP ALTERNATIVES

The background conditions included in this hypothetical analysis reflect observed impacts from cumulative air pollutant emission sources. Additionally, this is a cumulative analysis in the sense that it considers all reasonable foreseeable oil and gas development in the planning area regardless of surface or mineral ownership. However, this type of analysis is not able to address other reasonably foreseeable future activities (such as coal mine expansions and new power plant facilities). If future development locations are identified, site-specific NEPA analyses (including direct, indirect, and cumulative quantitative air quality impact analysis) will be performed. Regional cumulative air quality impact assessments that are directly relevant to the Little Snake RMP were not available at the time when the present study was performed (Scott Archer, BLM; personal communication 2007).

However, it is useful to point out there are a limited number of air pollutant emission sources located within the RMP area; there are a few cities and towns, very limited oil and gas extraction activities, a few coal mines, and two coal-fired power plants. These two power plants, the Hayden and Craig Power plants, have historically been shown to have a significant impact on visibility at the Mount Zirkel Class I area (Watson et al. 1996). As a result of that study, and a subsequent legal consent decree, the Hayden and Craig Power Plants have installed pollution controls resulting in emission reductions of approximately 14,000 tons/year SO_2 and 7,000 tons/year NOx for each plant (Scott Archer, BLM; personal communication, 2007). These two power plants are located closer to the mandatory federal Class I PSD areas (Mount Zirkel, Flat Tops, and Eagles Nest) than most of the assumed oil and gas activity in the Little Snake RMP area. The Little Snake RMP Alternatives A/B/C and D are projected to bring a maximum increase of 15 and 11 tons/year SO_2 to the region, respectively. These increases are approximately 0.2% of the SO_2 existing reduction from these two power plants combined. The Little Snake RMP Alternatives A/B/C and D are projected to increase NOx emissions in the study area by 1,066 and 825 tons/year, respectively. These increases are approximately 8% of the total emissions reduction at both power plants. Thus, as total SO_2 and NO_x emissions in the Little Snake RMP area are lowered in the future, cumulative air quality and AQRV will be reduced from historic levels.

4.0 REFERENCES

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APPENDIX A

Project Emissions Inventory for Natural Gas Well and Oil Well Construction And Natural Gas Well Production

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Table A.1.1.1: Alternatives A/B/C Assumptions

INPUTS & ASSUMPTIONS

Description	Value	Source	Notes
Control Efficiency (C) of watering	0.5	BLM 2003; Table APP_a21.xls	
TSP Emission Factor	1.2	EPA, *AP-42* , Volume I, Section 13.2.3 Heavy Construction	Tons TSP/acre-month
Conversion factor for TSP to PM-10	0.26	BLM 2003; Table APP_a21.xls	Percentage of TSP
Conversion factor for PM-10 to PM2.5	0.15	BLM 2003; Table APP_a21.xls	Percentage of PM-10
Total number of pads (year 30)	1637	BLM 2008	
Number wells to estimate construction emissions in yr 12	152	BLM 2008	
Compression per well	200	BLM 2008	
Average HP of the central compressor station	5,000	Pinedale 2005	
Total number of well head compressors	49	BLM 2008	

Well Emission Assumptions:

Emission factors derived from AP-42 or otherwise noted.

Gas compressors assumed to be BACT equipped.

Assume diesel fuel sulfur content of 15ppm for diesel engines.

Well condensate production assumed to be from wells with Best Available Control Technology (BACT).

Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10} for the following categories, heavy equipment traffic, natural gas compression, dehydrators, separators and flashing emissions.

Hazardous Air Pollutants (HAPS) assumed to be 10% of VOCs and formaldehyde added for gas compression emissions

For central compressors 30,000hp/1000 wells

For well head compressors, assume 200 Hp/compressor, installed on 30 of every 1,000 wells.

Assume natural gas heating value of 1,020 Btu/scf (BLM, 2003).

Assume that natural gas compressors would operate at full capacity.

86 is the total number of precipitation days for Kemmerer WY, Western Regional Climate Center.

Table A.1.1.2: Alternatives A/B/C Natural Gas and Oil Pad Construction Fugitive Dust Assumptions

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C)of watering	0.5	BLM 2003; Table APP_a21.xls	
TSP Emission Factor	1.2	EPA, *AP-42* , Volume I, Section 13.2.3 Heavy Construction Operations (1/95)	Tons TSP/acre-month
Conversion factor for TSP to PM-10	0.26	BLM 2003; Table APP_a21.xls	Percentage of TSP
Conversion factor for PM-10 to PM2.5	0.15	BLM 2003; Table APP_a21.xls	Percentage of PM-10
Number of wells drilled	**152**	**BLM 2008**	
Total number of pads	**1637**	**BLM 2008**	
Number of wells to estimate construction emissions	**152**	**BLM 2008**	
Number of well head compressors in 2021	**49**	**BLM 2008**	
HP compression per well	**200**	**EOG Resources**	
HP of central compressor stations	**5,000**	**BLM 2008**	

Table A1.1.3: Proposed Action, Natural Gas and Oil Pad Construction, Fugitive Dust Calculations

Emissions Estimation for Construction Activities: Long-Term Development

Area Disturbed for NG Wells	Emission Estimation Basis	Disturbed Area (acre) [a]	Avg. Number of Days to Complete	Total # of Well Pads or Stations	Total Disturbed Area (acre)	Emissions								
						(lb/well pad or lb/stn)			(ton/project)			lb/hr/source		ton/year/source
						TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Drilling Roads, Producing Roads, Drilling Well Pad & Producing Well Pad, New Pipeline and Electric Line	per Well Pad	2.75	7	1,637	4,502	770	200	30	630	164	25	1.19	0	0
Central Compressor Station	per station	1.50	4	10	15	240	62	9	1	0	0	0.65	0	0
Totals					4,517	**Total**			**631**	**164**	**25**			

[a] From gross surface disturbance projections BLM

Note: number of compressor stations are for new construction

TSP= 1.2 tpy/acre-month x 4,502 acres x 7/30 days x 0.5 dust control efficiency = 630 tons

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per day = 24

Table A1.1.4: Alternatives A/B/C Gas Analysis

Pinedale Frontier Formation Gas Analysis

Gas Component	Mol%	Mol%/100	Molecular Weight	Molecular Weight of each Component
N_2	1.2953	0.012953	28.01	0.363
Methane (C1)	83.3591	0.833591	16.04	13.371
CO_2	0.1265	0.001265	44.01	0.056
Ethane (C2)	8.7362	0.087362	30.07	2.627
Propane (C3)	4.1642	0.041642	44.10	1.836
I-Butane (iC4)	0.6661	0.006661	58.12	0.387
N-Butane (nC4)	0.9106	0.009106	58.12	0.529
I-pentane (iC5)	0.2129	0.002129	72.15	0.154
N-pentane (nC5)	0.1908	0.001908	72.15	0.138
Hexanes (C6)	0.1454	0.001454	84.18	0.122
Heptanes (C7)	0.1317	0.001317	100.20	0.132
Octanes (C8)	0.058	0.00058	114.23	0.066
Nonanes	0.0032	0.000032	114.23	0.004
TOTAL	**100**			**19.785**

MW = Mol%/100*MW

Methane (C1) = 0.833591*16.04 = 13.371

VOC = C_3^+ components = 3.368

VOC Weight Percent = 3.368/19.785*100 = 17.02%

BTU Value 1,189

Pinedale Frontier Formation Condensate Analysis

WELL NAME:	**Frontier Well**
COMPONENT	**MOL%**
H2S	0.0000
O2	0.0000
CO2	0.0000
N2	0.0000
C1	0.4064
C2	1.7056
C3	3.3635
IC4	2.2423
NC4	3.0113
IC5	3.8486
NC5	3.5648
Hexanes	14.1300
Heptanes	44.6335
Benzene	1.8256
Toluene	8.5229
E-Benzene	0.7922
Xylene	6.2070
n-C6	5.7245
2,2,4-Trimethylpentane	0.0219
Total	**100.000**

Table A1.1.5: Alternatives A/B/C Emissions Factors for Construction Equipment

Emission Factors for Construction Equipment						
Equipment	Emission Factors (g/hp-hr)					Equipment Category in AP-42 [a]
	NO_x	PM_{10}	SO_2	CO	VOCs	
Backhoe	8.81	0.81	0.86	2.71	0.97	Wheeled Loader
Dozer	7.81	0.69	0.85	2.15	0.75	Track-Type Tractor
Blade	7.14	0.63	0.87	1.54	0.36	Motor Grader
Trencher	11.01	0.90	0.93	4.60	1.01	Miscellaneous
Trackhoe	9.30	0.66	0.85	2.26	1.11	Track-Type Loader

[a] BLM, 2003, table APP_A21.

Source: EPA, *AP-42* , Volume II, Section II-7 Heavy-Duty Construction Equipment (9/85).

Table A1.1.6: Alternatives A/B/C Natural Gas and Oil Well Pad Construction Emissions

Construction Site	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hrs per Day	# of Oper. Days per Well Pad or per Station	# of Oper. Hrs per Well Pad or per Station	# of Well Pads or Stations	Emissions (lb/well pad, lb/station, or lb/project)					(ton/equipment type)					(ton/construction site)					lb/hour/source			ton/year/source	
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10} [a]	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	PM_{10}	SO_2	CO	NO_x	SO_2
Drilling Roads	Blade	100	1	80	10	3	30	152	38	3.3	4.6	8	1.9	3	0.3	0.3	0.6	0.1	5.5	0.5	0.6	1.4	0.4	0.1	0	0.3	0	0.0
	Backhoe	80	1	75	10	3	30	152	35	3.2	3.4	11	3.8	3	0.2	0.3	0.8	0.3						0.1	0	0.4	0	0.0
Producing Roads	Blade	100	1	80	10	3	30	152	38	3.3	4.6	8	1.9	3	0.3	0.3	0.6	0.1	5.5	0.5	0.6	1.4	0.4	0.1	0	0.3	0	0.0
	Backhoe	80	1	75	10	3	30	152	35	3.2	3.4	11	3.8	3	0.2	0.3	0.8	0.3						0.1	0	0.4	0	0.0
Drilling Well Pad	Backhoe	80	1	75	10	2	20	152	23	2.1	2.3	7	2.6	2	0.2	0.2	1	0.2	1.8	0.2	0.2	0.5	0.2	0.1	0	0.4	0	0.0
Producing Well Pad	Backhoe	80	1	75	10	2	20	152	23	2.1	2.3	7	2.6	2	0.2	0.2	1	0.2	1.8	0.2	0.2	0.5	0.2	0.1	0	0.4	0	0.0
New Pipeline	Blade	100	1	80	10	1	10	152	13	1.1	1.5	3	0.6	1	0.1	0.1	0.2	0.0	4	0.4	0.4	2	0.4	0.1	0	0.3	0	0.0
	Trencher	175	1	80	10	1	10	152	34	2.8	2.9	14	3.1	3	0	0	1	0						0.3	0	1.4	0	0
	Backhoe	80	1	75	10	1	10	152	12	1.1	1.1	4	1.3	1	0.1	0.1	0.3	0.1						0.1	0	0.4	0	0.0
Well Head Compressors	Dozer	350	1	80	8	2	16	49	77	6.8	8.4	21	7.4	2	0.17	0.21	0.5	0.2	2.9	0.3	0.3	0.8	0.3	0.4	1	1.3	0	0.00
	Backhoe	80	2	80	8	2	16	49	40	3.7	3.9	12	4.4	1	0.09	0.10	0.30	0.11						0.2	0	0.8	0	0.00
Central Compressor Station	Dozer	350	1	80	8	2	16	10	77	6.8	8.4	21	7.4	0	0.03	0.04	0.1	0.0	0.6	0.1	0.1	0.2	0.1	0.4	1	1.3	0	0.00
	Backhoe	80	2	80	8	2	16	10	40	3.7	3.9	12	4.4	0	0.02	0.02	0.06	0.02						0.2	0	0.8	0	0.00
																		Subtotal	**22**	**2.0**	**2.3**	**6.5**	**2.0**					

Table A1.1.7: Alternatives A/B/C Emissions Factors for Industrial Engines

Emission Factors for Industrial Engines (Tier IV)

Emission Source	Fuel Type	Emission Factors					
		Unit	NO_x	PM_{10}	SO_x	CO	VOC
Industrial Engine [a]	Diesel	lb/hp-hr	6.61E-04	3.30E-05	5.10E-05	5.73E-03	2.20E-04
Industrial Engine [b]	Diesel	lb/hp-hr	2.40E-02	5.73E-04	4.05E-04	5.50E-03	7.05E-04

[a] BLM 2008 from memo

[b] EPA, *AP-42* , Volume I, Section 3.4 Large Stationary Diesel and all Stationary Dual Fuel Engines (10/96).

Table A1.1.8: Alternatives A/B/C Emissions Estimates for Industrial Engines

Emissions Estimation for Industrial Engines

Construction Site Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Operating Hours per Day	# of Operating Days per Well	# of Operating Hours per Well	# of Wells	Emissions (lb/well)					Emissions (ton/equipment type)					Emissions (ton/project activity)					lb/hr/source			ton/yr/source	
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10} [a]	SO_x	CO	VOC	NO_x	PM_{10} [a]	SO_x	CO	VOC	PM_{10} [a]	SO_x	CO	NO_x	SO_x
Rig-up, Drilling, and Rig-down	Main Deck	2,100	1	42	24	25	600	152	350	17	27	2,911	117	27	1	2	221	9	30	1.5	2.4	254	10	0	0	5	0	0
	Auxiliary Pump	600	1	42	8	25	200	152	33	2	3	277	11	3	0	0	21	1						0	0	1	0	0
	Generator	150	1	75	24	10	240	152	18	1	1	155	6	1	0	0	12	0						0	0	1	0	0
Well Completion & Testing	Main Deck	2100	1	42	24	5	120	152	70	3	5	606	23	5	0	0	46	2	6	0	0	55	2	0	0	5	0	0
	Auxiliary Pump	225	1	42	24	4	96	152	6	0	0	52	2	0	0	0	4	0						0	0	1	0	0
	Power Swivel	150	1	75	24	4	96	152	7	0	1	62	2	1	0	0	5	0						0	0	1	0	0
									4.84E+02	**24**	**37**	**4,063**					**Subtotal**		**37**	**2**	**3**	**309**	**12**					

Table A1.1.9: Alternatives A/B/C Field Generator Emissions

Emission Factors for Field Generators

Emission Source	Fuel Type	Emission Factors					
		Unit	NO_x	PM_{10}	SO_x	CO	VOC
Industrial Engine [a]	Diesel	g/hp-hr	4.90E+00	2.20E-01	9.30E-01	3.70E+00	4.90E+00
Industrial Engine	Diesel	lbs/hp-hr	1.08E-02	4.80E-04	2.05E-03	8.20E-03	1.08E-02

[a] From USA - Nonroad Diesel Engines Tier 2 Emission Standards
Emission factors for a < 600 hp generator, (NOx & VOC = 4.9 g/bhp-hr)

Table A1.1.10: Alternatives A/B/C Temporary Emissions Estimates for Field Generators

Temporary Emissions Estimation for Field Generators

Construction Site Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Operating Hours per Day	# of Operating Days per Well	# of Operating Hours per Well	# of Wells	Emissions														
									(lb/well)					(ton/equipment type)					lb/hr/source			ton/yr/source	
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10} [a]	SO_x	CO	VOC	PM_{10}	SO_2	CO	NO_x	SO_2
Field Generators	Field Generators for Pumps & Lighting	100	1	75	12	8	96	152	78	3	15	59	78	6	0	1	4	6	0	0	1	0	0
													TOTALS	**6**	**0.3**	**1**	**4**	**6**					

Table A1.1.11: Alternatives A/B/C Estimate of Emissions Factors for Emissions from Well Construction Flaring

Emission Factors for Flaring

Unit	NO_x	PM_{10}	SO_2	CO
lb/MMscf	76.0	7.6	0.6	413.3
lb/MMBtu	6.80E-02	6.80E-03	5.37E-04	3.70E-01

Emission factors for NOx & CO Source: EPA, *AP-42* , Volume I, Section 13.5 Industrial Flares

Emission factors for PM10 & SO2 from EPA, AP-42, Volume I, Section 1.4 Natural Gas Combustio

Table A1.1.12: Alternatives A/B/C Emissions from Well Completion Flaring

Well Completion Flaring	Gas Production Estimate (MMSCF) per day	# of Days of Flaring	Av. Heat Content of Gas btu/scf	# of Wells	Emissions												
					(lb/well)				(tons)				lb/hr/source			ton/yr/source	
					NO_x	PM_{10}	SO_2	CO	NO_x	PM_{10} [a]	SO_x	CO	PM_{10}	SO_2	CO	NO_x	SO_2
Flaring	1	2	1020	152	139	15.2	1.2	755	11	1	0.1	57	0.3	0.0	15.7	0	0
							TOTALS		**11**	**1**	**0.1**	**57**					

Emissions = EVH where E= emission factor; V= gas volume; H= heat content

NOx= 0.068lbs/MMBtu*1.0 MMSCFD*1020 Btu/scf = 69.5 lbs per well* 2 days = 139 lbs per well

PM10 & SO2 Emissions = EV where E= emission factor; V= gas volume

PM10 = 7.6 lbs/MMSCF*1.0 MMSCFD = 7.6 lbs/well*2days = 15.2 lbs per well

<u>Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation</u>

hours per day = 24

Table A1.1.13: Alternatives A/B/C VOC Emissions from Well Completion Flaring

VOC Emissions Well Flaring

Well Completion Flaring	VOC Emission Factor lbs per well	# of Wells	VOC Emissions tons
Flaring	8,863	152	674

Assume average VOC content 17 %
Average Mole Weight 19.785
Gas production rate of 1.0 MMSCF per well per day
Assume 2 days of flaring

Flare Gas wt= 2.0 MMSCF*1,000,00scf/MMSCF*19.785 lbs/lbs-mole / 379.49scf/mole

VOC Emissions= 104,272 lbs/well*0.17VOC wt%*0.5 efficiency destruction = 8,863 lbs/well

HAPs are estimated at 10% of VOC amounts and are shown on total spread sheets
Assume same gas production rate for short term and long term new constructed wells of 1.0 MMSCFD

Table A1.1.14: Alternatives A/B/C Natural Gas and Oil Well Pad Construction Wind Erosion

Emission Factor: 0.3733 llb/hr/100m^2

Based on AP-42 Chapter 13.2.5 (EPA 2004), Industrial Wind Erosion using Jonah Field, Wyoming meterological data.

Control Efficiency: 50%

Disturbed Area:

Well Pad Construction:	2.75 acres	11128.87 m^2
Central Compressor Construction:	1.50 acres	6070.29 m^2
Access Road Construction:	3.00 acres	12140.58 m^2
Pipeline Construction:	0.50 acres	2023.43 m^2

Source Parameters
147 1-km area sources
sigma z=2.33 m

PM_{10} Emission Calculations:	**PM_{10} Emission Factor (llb/hr/100m^2)**	**$PM_{2.5}$ Emission Factor (llb/hr/100m^2)**	**Area 100 m^2**	**Control Efficiency (%)**	**PM_{10} Emissions (lb/hr)**	**$PM_{2.5}$ Emissions (lb/hr)**	**PM_{10} Emissions (g/sec)**	**$PM_{2.5}$ Emissions (g/sec)**
Well Pad Construction:	0.3733	0.1493	111.29	50	20.77	8.31	2.62	1.05
Central Compressor Construction	0.3733	0.1493	60.70	50	11.33	4.53	1.43	0.57
Resource Road Construction:	0.3733	0.1493	121.41	50	22.66	9.06	2.86	1.14
Pipeline Construction:	0.3733	0.1493	20.23	50	3.78	1.51	0.48	0.19
Total:					**58.54**	**23.41**	**7.38**	**2.95**

Assumptions for converting emissions to tons per year; used in AERMOD calculation
8760 = hours per year

Table A1.1.15: Alternatives A/B/C Fugitive Dust Emissions from Commuting Vehicles. Emission Factors for Road Traffic.

Emission Factors for Road Traffic

$$E\ (\text{lb/VMT}) = \frac{k\,(s/12)^{a}\,(W/3)^{d}}{(M/0.2)^{c}}$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	0.2	default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
CE = control efficiency for watering (%)	50	EPA, *Control of Open Fugitive Dust Sources*, Section 5.3.1 Watering of Unpaved Surfaces (1988)

Table A1.1.16: Alternatives A/B/C Fugitive Dust Emissions Estimates for Natural Gas and Oil Well Pad Construction Road Traffic

Emissions Estimation for Road Traffic

Construction Site Destination	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station	Miles Traveled per Well Pad or per Station	Total # of Well Pads or Stations	PM_{10}				$PM_{2.5}$				Emissions		
							Controlled Em. Factor (lb/VMT)	Emissions			Controlled Em. Factor (lb/VMT)	Emissions			lb/hr/source		ton/year/ source
								(lb/well pad, lb/stn, or lb/proj.)	(ton/veh. type)	(ton/const. site)		(lb/well pad, lb/stn, or lb/proj.)	(ton/veh. type)	(ton/const. site)	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Drilling Roads	Semi Trucks	60,000	6	2	12	1,637	1.21	15	12	12	0.18	2.2	1.8	1.8	0	0	0
Producing Roads	Semi Trucks	60,000	6	2	12	1,637	1.21	15	12	12	0.18	2.2	1.8	1.8	0	0	0
Drilling Well Pad	Haul Trucks	45,000	6	2	12	1,637	1.05	13	10	14	0.16	1.9	1.5	2.2	0	0	0
	Pickup Trucks	7,000	6	2	12	1,637	0.41	5.0	4		0.06	0.7	0.6		0	0	0
Producing Well Pad	Haul Trucks	45,000	6	2	12	1,637	1.05	13	10	14	0.16	1.9	1.5	2.2	0	0	0
	Pickup Trucks	7,000	6	2	12	1,637	0.41	5.0	4		0.06	0.7	0.6		0	0	0
New Pipeline	Haul Trucks	45,000	6	2	12	1,637	1.05	13	10	14	0.16	1.9	1.5	2	0	0	0
	Pickup Trucks	7,000	6	2	12	1,637	0.41	5	4		0.06	0.7	0.6		0	0	0
Electric Line	Haul Trucks	45,000	6	2	12	1,637	1.05	12.6	10	14	0.16	1.9	1.5	2.2	0	0	0
	Pickup Trucks	7,000	6	2	12	1,637	0.41	5.0	4		0.06	0.7	0.6		0	0	0
Well Head Compressors	Semi Trucks	60,000	6	2	12	49	1.21	15	0.4	1	0.18	2	0.1	0	0	0	0
	Haul Trucks	45,000	6	2	12	49	1.05	13	0		0.16	2	0.0		0	0	0
	Pickup Trucks	7,000	6	2	12	49	0.41	5	0		0.06	1	0.0		0	0	0
Central Compressor Station	Semi Trucks	60,000	6	2	12	10	1.21	15	0.1	0	0.18	2	0.0	0	0	0	0
	Haul Trucks	45,000	6	2	12	10	1.05	13	0		0.16	2	0.0		0	0	0
	Pickup Trucks	7,000	6	2	12	10	0.41	5	0		0.06	1	0.0		0	0	0
								Subtotal		**82**				**12**			

<u>Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation</u>

hours per day = 10

days per source = 21

Table A1.1.17: Alternatives A/B/C Fugitive Dust Emissions Estimates for Natural Gas and Oil Well Pad Construction Road Traffic

Emissions Estimation for Road Traffic

Construction Site Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station [a]	Miles Traveled per Well Pad or per Station	Total # of Wells or Stations	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lb/well)	PM_{10} Emissions (ton/veh. type)	PM_{10} Emissions (ton/proj. activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lb/well)	$PM_{2.5}$ Emissions (ton/veh. type)	$PM_{2.5}$ Emissions (ton/proj. activity)	Emissions lb/hr/source PM_{10}	Emissions lb/hr/source $PM_{2.5}$	Emissions ton/year/source $PM_{2.5}$
Rig-up, Drilling, and Rig-down	Semi Rig Transport & Drill Rig	80,000	6	5	30	1,637	1.40	42	34	191	0.21	6.3	5.1	29	0	0	0
	Fuel Haul Truck	50,000	6	5	30	1,637	1.10	33	27.1		0.17	5.0	4.1		0	0	0
	Mud Haul Truck, Water Hauling	60,000	6	5	30	1,637	1.21	36	30		0.18	5	4.5		0	0	0
	Rig Crew	7,000	6	5	30	1,637	0.41	12	10.1		0.06	1.9	1.5		0	0	0
	Rig Mechanics	12,000	6	5	30	1,637	0.54	16	13.3		0.08	2.4	2.0		0	0	0
	Co. Supervisor	7,000	6	5	30	1,637	0.41	12	10		0.06	1.9	1.5		0	0	0
	Tool Pusher	7,000	6	5	30	1,637	0.41	12	10.1		0.06	1.9	1.5		0	0	0
	Mud Logger	7,000	6	5	30	1,637	0.41	12	10.1		0.06	1.9	1.5		0	0	0
	Mud Engineer	7,000	6	5	30	1,637	0.41	12	10.1		0.06	1.9	1.5		0	0	0
	Logger, Engr Truck	45,000	6	5	30	1,637	1.05	31.4	25.7		0.16	4.7	3.9		0	0	0
	Drill Bit Delivery	7,000	6	5	30	1,637	0.41	12	10		0.06	1.9	1.5		0	0	0
Well Completion & Testing	Semi Casing Haulers	60,000	6	2	12	1,637	1.21	14.5	12	437	0.18	2.2	1.8	66	0	0	0
	Semi Completion, Unit Rig	120,000	6	8	48	1,637	1.71	82	67.2		0.26	12.3	10.1		0	0	0
	Semi Fracing Blender	85,000	6	2	12	1,637	1.44	17	14.1		0.22	2.6	2.1		0	0	0
	Semi Pumping Tank Battery	80,000	6	2	12	1,637	1.40	17	13.7		0.21	2.5	2.1		0	0	0
	Tubing Truck	60,000	6	2	12	1,637	1.21	14.5	11.9		0.18	2.2	1.8		0	0	0
	Haul Cementer, Pump Truck	85,000	6	2	12	1,637	1.44	17	14.1		0.22	2.6	2.1		0	0	0
	Haul Cementer, Cement Truck	60,000	6	8	48	1,637	1.21	58	47.5		0.18	8.7	7.1		0	0	0
	Haul Completion, Equip Truck	45,000	6	2	12	1,637	1.05	12.6	10.3		0.16	1.9	1.5		0	0	0
	Haul Service Tools	7,000	6	2	12	1,637	0.41	5.0	4.1		0.06	0.7	0.6		0	0	0
	Haul Perforators Logging Truck	45,000	6	2	12	1,637	1.05	12.6	10.3		0.16	1.9	1.5		0	0	0
	Haul Anchor Installation	40,000	6	2	12	1,637	0.99	11.9	9.7		0.15	1.8	1.5		0	0	0
	Haul Anchor Testing	12,000	6	2	12	1,637	0.54	6.5	5.3		0.08	1.0	0.8		0	0	0
	Haul Fracing Tank	40,000	6	2	12	1,637	0.99	11.9	9.7		0.15	1.8	1.5		0	0	0
	Haul Fracing Pump	85,000	6	2	12	1,637	1.44	17.3	14.1		0.22	2.6	2.1		0	0	0
	Haul Fracing Chemical	45,000	6	2	12	1,637	1.05	12.6	10.3		0.16	1.9	1.5		0	0	0
	Haul Fracing Sand	60,000	6	2	12	1,637	1.21	14.5	11.9		0.18	2.2	1.8		0	0	0
	Haul Fracing Other	85,000	6	2	12	1,637	1.44	17.3	14.1		0.22	2.6	2.1		0	0	0
	Haul Welders	12,000	6	2	12	1,637	0.54	6.5	5.3		0.08	1.0	0.8		0	0	0
	Haul Water Truck	60,000	6	8	48	1,637	1.21	58	48		0.18	9	7.1		0	0	0
	Pickup Cementer, Engineer	7,000	6	2	12	1,637	0.41	5.0	4.1		0.06	0.7	0.6		0	0	0
	Pickup Chasing Crew	10,000	6	2	12	1,637	0.49	5.9	4.9		0.07	0.9	0.7		0	0	0
	Pickup Completion Crew	10,000	6	8	48	1,637	0.49	23.7	19.4		0.07	3.6	2.9		0	0	0
	Pickup Completion Pusher	7,000	6	8	48	1,637	0.41	19.8	16.2		0.06	3.0	2.4		0	0	0
	Pickup Perforators Engineer	7,000	6	8	48	1,637	0.41	19.8	16.2		0.06	3.0	2.4		0	0	0
	Pickup Fracing Engineer	10,000	6	2	12	1,637	0.49	5.9	4.9		0.07	0.9	0.7		0	0	0
	Pickup Co. Supervisor	7,000	6	8	48	1,637	0.41	19.8	16.2		0.06	3.0	2.4		0	0	0
	Miscellaneous Supplies	7,000	6	8	48	1,637	0.41	19.8	16.2		0.06	3.0	2.4		0	0	0
	Pickup Roustabout Crew	12,000	6	2	12	1,637	0.54	6	5.3		0.08	1.0	0.8		0	0	0
Well Head Compressors	Semi Trucks	60,000	6	2	12	49	1.21	15	0.4		0.18	2	0.1		0	0	0
	Haul Trucks	45,000	6	2	12	49	1.05	13	0		0.16	2	0.0		0	0	0
	Pickup Trucks	7,000	6	2	12	49	0.41	5	0		0.06	1	0.0		0	0	0
Central Compressor Staton	Semi Trucks	60,000	6	2	12	10	1.21	15	0.1		0.18	2	0.0		0	0	0
	Haul Trucks	45,000	6	2	12	10	1.05	13	0		0.16	2	0.0		0	0	0
	Pickup Trucks	7,000	6	2	12	10	0.41	5	0		0.06	1	0.0		0	0	0
								Subtotal		628				94			
								TOTAL		711				107			

Table A1.1.18: Alternatives A/B/C Exhaust Emission Factors from Commuting Vehicles.

Emission Factors for Road Traffic

Vehicle		Emission Factors (g/mi)					
Type	Class	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	LDGT2	1.01	0.10	0.08	0.11	11.64	0.75
Heavy-Duty Diesel Truck	HDDV	8.13	1.96	1.81	1.63	17.09	4.83

[a] From BLM, 2003, APP_A21, table 1.1.2.2, estimated using EPA PART5 Model (1995)
[b] Including tire and brake wear emissions.
Source: EPA, *AP-42*, Volume II, Appendix H-117, Table 3.1A.2 Light Duty Gasoline Powered Trucks II and Appendix H-259, Table 7.1.2 Heavy Duty Diesel Powered Vehicles (High Altitude; Model Year 1991-1997; 50,000 mileage)

Table A1.1.19: Alternatives A/B/C Exhaust Emissions Estimates for Natural Gas and Oil Well Pad Construction Road Traffic

Emissions Estimation for Road Traffic

Construction Site Destination	Vehicle		Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station	Miles Traveled per Well Pad or per Station	Total # of Well Pads or Stations	Emissions																									
							(lb/well pad, lb/station, or lb/project)						(ton/vehicle type)						(ton/construction site)						lb/hr/source				ton/year/source		
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	PM_{10}	$PM_{2.5}$	SO_2	CO	NO_x	$PM_{2.5}$	SO_2
Drilling Roads	Semi Trucks	HDDV	6	2	12	1,637	0.22	0.05	0.05	0.04	0.45	0.13	0.2	0.04	0.04	0.04	0.4	0.1	0.2	0.04	0.04	0.04	0.4	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Producing Roads	Semi Trucks	HDDV	6	2	12	1,637	0.22	0.05	0.05	0.04	0.45	0.13	0.2	0.04	0.04	0.04	0.4	0.1	0.2	0.04	0.04	0.04	0.4	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1,637	0.22	0.05	0.05	0.04	0.45	0.13	0.2	0.04	0.04	0.04	0.4	0.1	0.2	0.04	0.04	0.04	0.6	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	LDGT2	6	2	12	1,637	0.03	0.003	0.002	0.003	0.31	0.02	0.0	0.002	0.002	0.002	0.3	0.02							0.00	0.000	0.000	0.001	0.00	0.00	0.0
Producing Well Pad	Haul Trucks	HDDV	6	2	12	1,637	0.22	0.05	0.05	0.04	0.45	0.13	0.2	0.04	0.04	0.04	0.4	0.1	0.2	0.04	0.04	0.04	0.6	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	LDGT2	6	2	12	1,637	0.03	0.003	0.002	0.003	0.31	0.02	0.0	0.002	0.002	0.002	0.3	0.02							0.00	0.000	0.000	0.001	0.00	0.00	0.0
New Pipeline	Haul Trucks	HDDV	6	2	12	1,637	0.22	0.05	0.05	0.04	0.45	0.13	0.2	0.0	0.0	0.04	0.4	0.1	0.2	0.0	0.0	0.0	0.6	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	LDGT2	6	2	12	1,637	0.03	0.00	0.00	0.00	0.31	0.02	0.0	0.002	0.002	0.002	0.3	0.02							0.00	0.00	0.00	0.00	0.00	0.00	0.0
Electric Line	Haul Trucks	HDDV	6	2	12	1,637	0.22	0.05	0.05	0.04	0.45	0.13	0.2	0.04	0.04	0.04	0.4	0.10	0.2	0.04	0.04	0.04	0.6	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	LDGT2	6	2	12	1,637	0.03	0.003	0.002	0.003	0.31	0.02	0.0	0.002	0.002	0.002	0.3	0.02							0.00	0.000	0.000	0.001	0.00	0.00	0.0
Central Compressor Station	Semi Trucks	HDDV	6	2	12	10	0.22	0.05	0.05	0.04	0.45	0.13	0.0	0.000	0.000	0.000	0.00	0.001	0.0	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Trucks	HDDV	6	2	12	10	0.22	0.05	0.05	0.04	0.45	0.13	0.0	0.000	0.000	0.000	0.00	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	LDGT2	6	2	12	10	0.03	0.00	0.00	0.00	0.31	0.02	0.0	0.000	0.000	0.000	0.0	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
																		Subtotal	**1.1**	**0.3**	**0.2**	**0.2**	**3.2**	**0.7**							

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per day = 10

days per source = 21

Table A1.1.20: Alternatives A/B/C Emissions Estimates for Natural Gas and Oil Well Construction Road Traffic

Emissions Estimation for Road Traffic

Construction Site Activity	Vehicle Type	Vehicle Class	Round Trip Distance (mi)	# of Round Trips per Well Pad or	Miles Traveled per Well or per Station	Total # of Wells or Stations	Emissions																								
							(lb/well)						(ton/vehicle type)						(ton/project activity)						lb/hr/source				ton/year/source		
							NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	PM_{10}	$PM_{2.5}$	SO_2	CO	NO_x	$PM_{2.5}$	SO_2
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	12	72	152	1.29	0.31	0.29	0.26	2.71	0.77	0.1	0.02	0.02	0.02	0.2	0.06							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Fuel Haul Truck	HDDV	6	12	72	152	1.29	0.31	0.29	0.26	2.71	0.77	0.1	0.02	0.02	0.02	0.2	0.1							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Mud Haul Truck, Water	HDDV	6	12	72	152	1.29	0.31	0.29	0.26	2.71	0.77	0.1	0.0	0.0	0.0	0.2	0.1							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Rig Crew	LDGT2	6	12	72	152	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.001	0.001	0.001	0.1	0.01							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Rig Mechanics	HDDV	6	2	12	152	0.22	0.05	0.05	0.04	0.45	0.13	0.0	0.004	0.004	0.003	0.0	0.01							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Co. Supervisor	LDGT2	6	12	72	152	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.00	0.00	0.00	0.1	0.01	0.5	0.1	0.1	0.1	1.7	0.3	0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Tool Pusher	LDGT2	6	12	72	152	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.0	0.0	0.0	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Mud Logger	LDGT2	6	12	72	152	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.0	0.0	0.0	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Mud Engineer	LDGT2	6	12	72	152	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.0	0.0	0.0	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Logger, Engr Truck	HDDV	6	12	72	152	1.29	0.31	0.29	0.26	2.71	0.77	0.1	0.0	0.0	0.0	0.2	0.1							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Drill Bit Delivery	LDGT2	6	12	72	152	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.00	0.00	0.00	0.1	0.01							0.00	0.00	0.00	0.01	0.00	0.00	0.0
Well Completion & Testing	Semi Casing Haulers	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.03							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Semi Completion, Unit Rig	HDDV	6	20	120	152	2.15	0.52	0.48	0.43	4.52	1.28	0.2	0.04	0.04	0.03	0.3	0.10							0.00	0.00	0.00	0.02	0.00	0.00	0.0
	Semi Fracing Blender	HDDV	6	4	24	152	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Semi Pumping Tank Battery	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.03							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Tubing Truck	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.03							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Cementer, Pump Truck	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.03							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Cementer, Cement Truck	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.03							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Completion Equip Truck	HDDV	6	20	120	152	2.15	0.52	0.48	0.43	4.52	1.28	0.2	0.04	0.04	0.03	0.3	0.10							0.00	0.00	0.00	0.02	0.00	0.00	0.0
	Haul Service Tools	LDGT2	6	6	36	152	0.08	0.01	0.01	0.01	0.92	0.06	0.0	0.00	0.00	0.00	0.1	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Perforators Logging Truck	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.03							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Anchor Installation	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.03							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Anchor Testing	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.03							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Fracing Tank	HDDV	6	4	24	152	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Fracing Pump	HDDV	6	4	24	152	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Fracing Chemical	HDDV	6	4	24	152	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Fracing Sand	HDDV	6	4	24	152	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Fracing Other	HDDV	6	4	24	152	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.01	0.1	0.02	1.6	0.4	0.3	0.3	4.3	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Welders	HDDV	6	4	24	152	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Water Truck	HDDV	6	20	120	152	2.15	0.52	0.48	0.43	4.52	1.28	0.2	0.04	0.04	0.03	0.3	0.10							0.00	0.00	0.00	0.02	0.00	0.00	0.0
	Pickup Cementer, Engineer	LDGT2	6	6	36	152	0.08	0.01	0.01	0.01	0.92	0.06	0.0	0.00	0.00	0.00	0.1	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Chasing Crew	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.0	0.0	0.0	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Pickup Completion Crew	HDDV	6	20	120	152	2.15	0.52	0.48	0.43	4.52	1.28	0.2	0.0	0.0	0.0	0.3	0.1							0.00	0.00	0.00	0.02	0.00	0.00	0.0
	Pickup Completion Pusher	LDGT2	6	20	120	152	0.27	0.026	0.020	0.030	3.08	0.20	0.02	0.002	0.002	0.002	0.2	0.02							0.00	0.000	0.000	0.015	0.00	0.00	0.00
	Pickup Perforations Engineer	LDGT2	6	20	120	152	0.27	0.026	0.020	0.030	3.08	0.20	0.02	0.002	0.002	0.002	0.2	0.02							0.00	0.000	0.000	0.015	0.00	0.00	0.00
	Pickup Fracing Engineer	HDDV	6	4	24	152	0.43	0.104	0.096	0.086	0.90	0.26	0.03	0.008	0.007	0.007	0.1	0.02							0.00	0.000	0.000	0.004	0.00	0.00	0.00
	Pickup Co. Supervisor	LDGT2	6	20	120	152	0.27	0.026	0.020	0.030	3.08	0.20	0.02	0.002	0.002	0.002	0.2	0.02							0.00	0.000	0.000	0.015	0.00	0.00	0.00
	Pickup Misc Supplies	LDGT2	6	20	120	152	0.27	0.026	0.020	0.030	3.08	0.20	0.02	0.002	0.002	0.002	0.2	0.02							0.00	0.000	0.000	0.015	0.00	0.00	0.00
	Pickup Roustabout Crew	HDDV	6	6	36	152	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
Well Head Compressors	Semi Trucks	HDDV	6	6	150	49	2.69	0.65	0.60	0.54	5.65	1.60	0.1	0.016	0.015	0.013	0.14	0.039							0.00	0.00	0.00	0.03	0.00	0.00	0.0
	Haul Trucks	HDDV	6	6	36	49	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.004	0.004	0.003	0.03	0.01							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Pickup Trucks	LDGT2	6	6	36	49	0.08	0.01	0.01	0.01	0.92	0.06	0.0	0.000	0.000	0.000	0.0	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
Central Compressor Station	Semi Trucks	HDDV	6	6	150	8	2.69	0.65	0.60	0.54	5.65	1.60	0.0	0.003	0.002	0.002	0.02	0.006							0.00	0.00	0.00	0.03	0.00	0.00	0.0
	Haul Trucks	HDDV	6	6	36	8	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.001	0.001	0.001	0.01	0.00							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Pickup Trucks	LDGT2	6	6	36	8	0.08	0.01	0.01	0.01	0.92	0.06	0.0	0.000	0.000	0.000	0.0	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
																		Subtotal	**2.1**	**0.5**	**0.4**	**0.4**	**6**	**1.1**							

Table A1.1.21: Alternatives A/B/C Emission Factors for Central Compressor Stations

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Emission Factors (g/hp-hr) [a,d]						
			NOx [a,]	PM_{10} [b,c]	SO_2 [b]	CO	VOC	HCHO	Formaldehyde
Central Compressor Station	Rich Burn	5,000	1.00	5.2E-03	2.0E-03	2.00	1.00	0.07	0.08

[a] From State of Wyoming AQD BACT for all except Formaldehyde
[b] From BLM, 2003. Source: EPA, *AP-42* , Volume I, Section 3.2 Natural Gas-Fired Reciprocating Engines, Table 3.2-2 & 3.2-3 (7/00).
[c] From BLM, 2003. Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}.
\ [d] Formaldehyde emission factor is from Table B.2.10 of Johah Infill Drilling Project Technical Support Document, which references the Bird Canyon Permit

Table A1.1.22: Alternatives A/B/C Emissions Estimates for Central Compressor Stations

Emissions Estimation for Compressors

Type of Compressors	Total # of Operating Station-Year	Operating Hours per Year	Total Emissions (ton/year)					
			NOx	PM_{10}	SO_2	CO	VOC	HCHO
Central Compressor Station	10	8,760	483	3	1	966	483	34
		Total	**483**	**3**	**1**	**966**	**483**	**34**

Emissions per Compressor = emission factor g/hp-hr*compressor engine hp rating*(453.6g/lb)

NOX Emissions= (1.0 g/hp-hr*5,000 hp)/453.6g/lb = 110.23 lb per hour*8760 hours*10 stations/2000lb per ton = 483 tpy

Table A1.1.23: Alternatives A/B/C Emission Factors for Well Head Compressors

Compressor			Make	Model	Capacity (hp)	Emission Factors (g/hp-hr)						
						NOx [a, d]	PM_{10} [b,c]	SO_2 [b]	CO	VOC	HCHO	CH_2O [e]
Well Head Compressors	Lean Burn	50%	Caterpillar	G3516LE	200	1.00	6.6E-02	2.0E-03	0.50	1.0E+00	0.07	0.08
	Rich Burn	50%	Waukesha	7044GSI	200	1.00	6.6E-02	2.0E-03	2.00	1.0E+00	0.05	0.08

[a] BACT
[b] From BLM Rawlins RMP, 2005. Source: EPA, *AP-42* , Volume I, Section 3.2 Natural Gas-Fired Reciprocating Engines, Table 3.2-2 & 3.2-3 (7/00).
[c] From BLM Rawlins RMP, 2005. Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}.
[d] Equipped with oxidizing catalyst and from Caterpillar gas engine technical data
[e] Formaldehyde emission factor is from Table B.2.10 of Johah Infill Drilling Project Technical Support Document, which references the Bird Canyon Permit

Table A1.1.24: Alternatives A/B/C Emissions Estimates for Well Head Compressors

Emissions Estimation for Compressors

Type of Compressors	Total # of Operating Station-Year	Operating Hours per Year	Total Emissions (ton/year)						
			NOx	PM_{10}	SO_2	CO	VOC	HCHO*	CH_2O
Well Head Compressors	49	8,760	94.63	6.25	0.19	118.29	94.63	5.68	7.57
		Total	**94.63**	**6.25**	**0.19**	**118.29**	**94.63**	**5.68**	**7.57**

Total conventional well production based on 50,000 CF/day/well
*HCHO= formaldehyde

Table A1.125: Alternatives A/B/C VOC Emission Factors for Dehydration and Condensate Tank Flashing During Natural Gas Production Operations

VOC Emission Factors Dehydration and Condensate Tank Flashing

	(lb/hr/source)[b]						(ton/year/source)[b]					
Dehydration VOC Emissions	**VOC**	**Benzene**	**Toluene**	**Ethyl-benzene**	**Hexane**	**Xylene**	**VOC**	**Benzene**	**Toluene**	**Ethyl-benzene**	**Hexane**	**Xylene**
0.3759 lb/hr per MMSCF per day [a]	2.79	0.20	0.68	0.05	0.03	0.66	12.22	0.86	2.99	0.24	0.15	2.87

[a] Generated from GRI-GLYCalc Version 4.0 and South Piney AQ Analysis
[b] Generated from GRI-GLYCalc Version 4.0
Emission factor changed from 0.2164 lb/hr to 0.3759 lb/hr due to adding C9 and C10 components from S. Piney gas analysis

Flashing Emissions	
0.023 lb/hr controlled [a]	0.387 lb/hr uncontrolled [a]

[a] from E&P Tank Version 2.0 as per South Piney AQ Analysis

Table A1.1.26: Alternatives A/B/C VOC Emissions for Dehydration and Condensate Tank Flashing During Natural Gas Production Operations

Estimate for Dehydration VOC Emissions per year

VOC Emission Factor lb/hr	Total Number of Wells	Hours of Operation per year	Total VOC Emissions tpy	(lb/hr/source) VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	ton/year/source Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
0.3759	3031	8760	4990	1139	80	278	22	14	268	352	1219	98	60	1173

Assume 0.3 MMSCF gas production per well per day, based on input from Questar

Estimate for VOC Controlled Condensate Tank Flashing and Flaring Emissions per year

Total Field Condensate bbl/day	Total Number of Condensate Tanks	VOC Controlled Emission Factor lb/hr	Hours of Operation per year	Total VOC Emissions tpy	(lb/hr/source) VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	ton/year/source Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
21,217	2,122	0.023	8760	214	49	3	12	1	1	11	15	52	4	3	50

Assume 10 barrels of condensate and produced water per MMCF
HAP emissions represented on summary tables
Assume 70% of condensate tanks operate with a combustion chamber emission control device

Estimate for VOC Uncontrolled Condensate Tank Flashing Emissions per year

Total Field Condensate bbl/day	Total Number of Condensate Tanks	VOC Uncontrolled Emission Factor lb/hr	Hours of Operation per year	Total VOC Emissions tpy	(lb/hr/source) VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	ton/year/source Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
9,093	909	0.387	8760	1541	352	25	86	7	4	83	109	376	30	18	362

Assume 10 barrels of condensate and produced water per MMCF
HAP emissions represented on summary tables
Assume 30% of condensate tanks operate without an emission control device
Assume one tank per well

Table A1.1.27: Alternatives A/B/C Emissions Factors for Dehydrator Heaters for Production Operations

Production Emissions

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10} [a]	SO_2	CO	VOC
lb/MMscf	100	7.6	0.6	84	5.5
lb/MMBtu [b]	9.80E-02	7.45E-03	5.88E-04	8.24E-02	5.39E-03

[a] From BLM, 2003. Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}.

[b] From BLM, 2003. Assumed a fuel heating value of 1,020 Btu/scf.

Source: EPA, *AP-42* , Volume I, Section 1.4 Natural Gas Combustion (7/98).

Table A1.1.28: Alternatives A/B/C Emissions Estimates for Dehydrator Heaters

Emission Estimate for Dehydrator Heaters

Operating Hours per Year [a]	Dehydrator Heater Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Wells	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.10	0.21	3031	33	2	0	27	2	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day

Assume Dehydrator Heater Operation at each well site

HAP emissions represented on summary tables

Table A1.1.29: Alternatives A/B/C Emission Factors for Three-Phase Separator Heaters

Emission Factors for Three-Phase Separator Heaters

Unit	NO_x	PM_{10} [a]	SO_2	CO	VOC
lb/MMscf	100	7.6	0.6	84	5.5
lb/MMBtu [b]	9.80E-02	7.45E-03	5.88E-04	8.24E-02	5.39E-03

Table A1.130: Alternatives A/B/C Emission Estimates for Three-Phase Separator Heaters

Emission Estimates for Three Phase Separator Heaters

Operating Hours per Year [a]	Separator Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Wells	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.75	1.61	3031	244	19	1	205	13	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day
Assume Dehydrator Heater Operation at each well site

Table A1.1.31: Alternatives A/B/C Emission Factors for Condensate Tank Heaters

Emission Estimates for Condensate Tank Heaters

Operating Hours per Year [a]	Tank Heater Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Condensate Tanks	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.50	1.07	3031	163	12	1	137	9	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day

Assume a separator and heater for each well

Table A1.1.32: Alternatives A/B/C Emission Estimates for Produced Water Tank Heaters

Emission Estimates for Produced Water Tank Heaters

Operating Hours per Year [a]	Tank Heater Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Produced Water Tanks	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.50	1.07	3031	163	12	1	137	9	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day

Assume a heater for each tank

Table A1.1.33: Alternatives A/B/C Fugitive Dust Emission Factors for Production Operations Road Traffic

Emission Factors for Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^a (W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	default value in EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98)
CE = control efficiency for watering (%)	50	EPA, *Control of Open Fugitive Dust Sources* , Section 5.3.1 Watering of Unpaved Surfaces

Table A1.1.34: Alternatives A/B/C Fugitive Dust Emissions Estimates for Production Operations Road Traffic

Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle Type	Av. Vehicle Weight (lb)	Total # of Operating Stations	Total # Inspection Visits per Station per year	Total # of Inspection Visits per year	Total # Miles per Inspection	PM_{10} Em. Factor (lb/VMT) a	PM_{10} Emissions (lb/stn-yr)	PM_{10} Emissions (ton/proj.)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lb/stn-yr)	$PM_{2.5}$ Emissions (ton/proj.)	Emissions (lb/hr/stn) PM_{10}	Emissions (lb/hr/stn) $PM_{2.5}$
Inspection Visits for Compressor Stations	Central Compressor Station	Pickup Truck	7,000	10	52	520	10	0.63	6.3	1.6	0.09	0.9	0.25	0.0050609	0.001316
								Total		**1.6**			**0.2**		

[a] BLM, 2003. Table APP_A21, field and sales compressors are visited using a 200 hp pick up truck (4 wheels) once a week

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per inspection = 24

Table A1.1.35: Alternatives A/B/C Exhaust Emission Factors for Production Operations Road Traffic

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] From BLM, 2003, table 1.1.2.2

[b] Including tire and brake wear emissions.

Source: EPA, *AP-42* , Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II (High Altitude; Model Year 1991-1997; 50,000 mileage) (1985).

Table A1.1.36: Alternatives A/B/C Exhaust Emission Estimates for Production Operations Road Traffic

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle Type	Av. Vehicle Weight (lb)	Total # of Operating Stations	Total # Inspection Visits per Station per year	Total # of Inspection Visits per year	Total # Miles per Inspection	Emissions																										
								(lb/station-yr)						(ton/project)											(lb/hr/stn)									
								NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Inspection Visits for Compressor Stations	Central Compressor Station	Pickup Truck	7,000	10	52	520	10	0.02	0.0022	0.0017	0.00	0.26	0.02	0.006	0.001	0.000	0.001	0.067	0.004	0	0	0	0	0	1.7E-06	1.3E-06	1.99E-06	0.00021	1.3E-05	0	0	0	0	0
													Total	**0.01**	**0.00**	**0.00**	**0.00**	**0.07**	**0.00**															

[a] BLM, 2003. Table APP_A21, field and sales compressors are visited using a 200 hp pick up truck (4 wheels) once a week

Emissions per well = emission factor g/mile*total miles per inspection/453.6 g/lb

Table A1.1.37: Alternatives A/B/C Fugitive Dust Emission Factors for Well Workover Road Traffic

Emission Factors for Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^a (W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98))
W= mean vehicle weight (tons)	60	Assume workover rig 120,000 lbs
W= mean vehicle weight (tons)	30	Assume haul truck 60,000 lbs
W = mean vehicle weight (tons)	3.5	Assume pickup truck weight of 7,000 lbs
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads
CE = control efficiency for watering (%)	50	EPA, *Control of Open Fugitive Dust Sources* ,

Table A1.1.38: Alternatives A/B/C Fugitive Dust Emission Estimates for Well Workover Road Traffic

Fugitive Dust Emissions Estimation for Road Traffic																
Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi)	# of Round Trips per Well	Miles Traveled per Well	Total # of Wells Drilled	PM_{10}			$PM_{2.5}$			lb/hr/well		ton/year/wel
							Emission Factor (lb/VMT)	Emissions (lb/well)	Emissions ton/proj.	Emission Factor (lb/VMT)	Emissions (lb/well)	Emissions (ton/proj.)	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Well Workover	Workover Rig	120,000	3	2	6	152	2.6	16	1	0.1	1	0.0	0.32689	0.012	#####
	Haul Truck	60,000	3	2	6	152	1.8	11	1	0.4	2	0.2	0.23114	0.044	#####
	Pickup Truck	7,000	3	2	6	152	0.6	4	0	0.2	1	0.1	0.07895	0.022	#####
							Total		**2**			**0.3**			

[a] BLM, 2003. Table APP_A21.
[b] BLM, 2003. No dust control measures would be applied.

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only, Workover Rig) = 24
hours per round trip (driving time only, Haul Truck) = 24
hours per round trip (driving time only, Pickup Truck) = 24

Table A1.1.39: Alternatives A/B/C Exhaust Emission Factors for Well Workover On-Site Industrial Engines

Emission Factors for Industrial Engines					
Fuel Type	Emission Factors (lb/hp-hr)				
	NO_x	PM_{10}	SO_x	CO	VOC
Diesel	2.40E-02	5.73E-04	4.05E-04	5.50E-03	7.05E-04

EPA, *AP-42* , Volume I, Section 3.4 Large Stationary Diesel and all Stationary Dual Fuel Engines (10/96).

Table A1.1.40: Alternatives A/B/C Exhaust Emission Estimates for Well Workover On-Site Industrial Engines

On-Site Exhaust Emissions Estimation for Industrial Engines

Activity	Equipment	Capacity (hp)	Ave. Operating Load Factor (%)	Operating Hours per well	Total # of Wells Drilled	Emissions (lb/well)					Emissions (ton/project)					Emissions lb/hr/source									ton/year/source)							
						NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM_{10}	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	NO_x	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Well Workover	Truck-Mounted Unit	600	0.7	30	3,031	302	7	5	69	9	458	10.9	7.7	105.0	13.5	0.2	0.2	2.3	0.3	0	0	0	0	0	0.17	2.31	0.2961	0	0	0	0	0

Emissions per well = emission factor lb/hp-hr*engine hp rating*operating hours*engine load factor %

NOx Emissions= $\frac{\text{302 lb/well*3,031 wells}}{\text{2000lb/ton}}$ = 458 tons

Table A1.1.41: Alternatives A/B/C Exhaust Emission Factors for Well Workover Road Traffic

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light Duty Gasoline Truck (LDGT2)	1.01	0.10	0.08	0.11	11.64	0.75
Heavy-Duty Diesel Truck (HDDV)	8.13	1.96	1.81	1.63	17.09	4.83

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).
[b] BLM, 2003. Including tire and brake wear emissions.
Source: EPA (1985), AP-42, Volume II, Appendix H-259, Table 7.1.2 Heavy Duty Diesel Powered Vehicles (High Altitude; Model Year 1991-1997; 50,000 mileage).

Table A1.1.42: Alternatives A/B/C Exhaust Emission Estimates for Well Workover Road Traffic

On-Road Exhaust Emissions Estimation for Road Traffic

Activity	Vehicle		Round Trip Distance (mi)	Round Trip Per Well	Miles Traveled per Well	Total # of Wells Drilled	Emissions (lb/well)						(ton/project)					
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC
Well Workover	Workover Rig	HDDV	3	2	6	3,031	0.1	0.0	0.0	0.0	0.2	0.1	0.2	0.0	0.0	0.0	0.3	0.1
	Haul Truck	HDDV	3	2	6	3,031	0.1	0.0	0.0	0.0	0.2	0.1	0.2	0.0	0.0	0.0	0.3	0.1
	Pickup Truck	LDGT2	3	2	6	3,031	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0
						TOTAL							**0.3**	**0.1**	**0.1**	**0.1**	**0.9**	**0.2**

Activity	Type	(lb/hr/source) PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Well Workover	Workover Rig	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0
	Haul Truck	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0
	Pickup Truck	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0

Activity	Type	(tons/year/source) NO_x	$PM_{2.5}$	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Well Workover	Workover Rig	0.0	0.0	0.0	0.0	0	0	0	0	0
	Haul Truck	0.0	0.0	0.0	0.0	0	0	0	0	0
	Pickup Truck	0.0	0.0	0.0	0.0	0	0	0	0	0

Workover Rig

Emissions per well = $\frac{\text{emission factor g/mile*distance in miles}}{(453.6 \text{ g/lb})}$

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only, Workover Rig) = 24

hours per round trip (driving time only, Haul Truck) = 24

hours per round trip (driving time only, Pickup Truck) = 24

Table A1.1.43: Alternatives A/B/C Fugitive Dust Emission Factors for Well and Pipeline Road Traffic

Emission Factors for Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^a (W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
Control efficiency for watering (%) =	50	EPA, *Control of Open Fugitive Dust Sources*, Section 5.3.1 Watering of Unpaved Surfaces (1988)

Table A1.1.44: Alternatives A/B/C Fugitive Dust Emission Estimates for Well and Pipeline Road Traffic

Well & Pipeline Fugitive Dust Emissions Estimation for Road Traffic

Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi/day)	# of Wells Visited per Day [a]	# of Visits per Well per Year [b]	Miles Traveled per Well per Year	Total # of Operating Well-Yr	PM_{10}			$PM_{2.5}$		
								Em. Factor	Emissions		Em. Factor	Emissions	
								(lb/VMT) [c]	(lb/well-yr)	(ton/proj.)	(lb/VMT)	lb/well-yr	(ton/proj.)
Visits for Inspection and Repair	200-hp Pickup	7,000	75	120	2	1.25	3,031	0.63	0.8	1	0.09	0.1	0.2

[a] BLM, 2003. Table APP_A21.xls
[b] BLM, 2003. Table APP_A21.xls
[c] BLM, 2003. Table APP_A21.xls

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation
hours per round trip (driving time only,200-hp Pickup) = 24

Table A1.1.45: Alternatives A/B/C Exhaust Emission Factors for Well and Pipeline Road Traffic

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] From BLM, 2003, table 1.1.2.2

[b] From BLM, 2003, table 1.1.2.2; including tire and brake wear emissions.

Source: EPA, *AP-42* , Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II (High Altitude; Model Year 1991-1997; 50,000 mileage) (1985).

Table A1.1.46: Alternatives A/B/C Exhaust Emission Estimates for Well and Pipeline Road Traffic

Well & Pipeline Exhaust Emissions Estimation for Road Traffic

Activity	Vehicle		Round Trip Distance (mi/day)	# of Wells Visited per Day [a]	# of Visits per Well per Year [b]	Miles Traveled per Well per Year	Total # of Operating Well-Yr	Emissions (lb/well-yr)					
	Type	Class						NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC
Visits for Inspection and Repair	200-hp Pickup	LDGT2	75	120	2	1.25	3,031	0.00	0.000	0.000	0.000	0.0	0.00

Activity	Emissions (ton/project)						Emissions (lb/hr/source)									
	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Visits for Inspection and Repair	0.00	0.000	0.000	0.000	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0

Activity	Emissions (ton/year/source)								
	NO_x	$PM_{2.5}$	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Visits for Inspection and Repair	0.00	0.00	0.00	0.00	0	0	0	0	0

[a] From BLM, 2003, APP_A21, table 1.2.5.2
[b] Wells visited once per month

<u>Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation</u>
hours per round trip (driving time only,200-hp Pickup) = 24

Table A1.1.47: Alternatives A/B/C Road Maintenance Emissions Estimation Information

Maintenance [a]	Equipment/Vehicle			Road Length Worked On per Day	# of Operating Hours per Day
	Type	Fuel	Capacity (hp)		
Summer	Heavy Equipment [b]	Diesel	135 [c]	6	10
	Commuting Vehicle	Gasoline	225	6 [d]	1 [e]
Winter	Heavy Equipment [b]	Diesel	135 [c]	5	10
	Commuting Vehicle	Gasoline	225	6 [d]	1.5 [e]

[a] BLM, 2003. Road maintenance would be made twice in summer and once in winter every year.
[b] BLM, 2003. Assume a motor grader.
[c] BLM, 2003. Assume 135 hp.
[d] BLM, 2003. Average round trip mileage on unpaved road.
[e] BLM, 2003. Assume one round trip per day.

Estimation of Total and Cumulative Length of Roads

Total Length of Roads Built (mi/pad) [a,b]	0.9
Cumulative Length of Roads Maintained [c] (mi)	2,728

[a] Reflects combination of drilling and producing roads
[b] = drilling roads 0.5 mile per well and access roads are 0.4 mile per well for a total of 0.9 mile per well pad
[c] = 0.9 miles of road built per pad*1861 well pads = 1,675 miles of roads to maintain

Estimation of Total Operation Days and Hours

Season	# of Operation per Year	Cumulative Length of Roads (mi-yr)	Road Length Worked On (mi/day)	# of Operating Hours per Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	2,728	6	10	909	9,093
Winter	1	2,728	5	10	546	5,456
				Total	**1,455**	**14,549**

Table A1.1.48: Alternatives A/B/C Road Maintenance Fugitive Dust Emissions Factors for Grader

Emission Factors for Grader

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

[a] Assumed a mean vehicle speed (S) of 5 mph. (BLM, 2003)

Source: EPA, *AP-42* , Volume I, Section 11.9 Western Surface Coal Mining (10/9

Table A1.1.49: Alternatives A/B/C Road Maintenance Fugitive Dust Emissions Estimates for Grader

Fugitive Dust Emissions Estimation for Grader

Activity	Equipment	Total # of Operating Hours [a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10} Em. Factor (lb/VMT)	PM_{10} Emissions (ton/proj.)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (ton/proj.)	lb/hr/well PM_{10}	lb/hr/well $PM_{2.5}$	ton/year/well $PM_{2.5}$
Road Maintenance	Grader	8,729	5	43,646	0.765	17	0.069	1.5	0.153	0.013864	0.0005

[a] Assumed that a grader would operate for 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities. (BLM, 200

Table A1.1.50: Alternatives A/B/C Road Maintenance Exhaust Emission Factors for Grader

Emission Factors for Grader

Equipment		Emission Factors (g/hp-hr)			
	NO_x	PM_{10} [a]	SO_2	CO	VOC
Grader	7.14	0.63	0.87	1.54	0.36

[a] Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}. (BLM, 2003)

Source: EPA, *AP-42* , Volume II, Section II-7 Heavy-Duty Construction Equipment (1985).

Table A1.1.51: Alternatives A/B/C Road Maintenance Exhaust Emission Estimates for Grader

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions																	
				(lb/hr)					(ton/project)					(ton/year/source)							
				NO_x	PM_{10} [b]	SO_x	CO	VOC	NO_x	PM_{10} [b]	SO_x	CO	VOC	NO_x	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Road Maintenance	Grader	135	8,729	2.13	0.19	0.26	0.46	0.11	9	0.8	1.1	2.0	0.5	0	0	0	0	0	0	0	0

[a] Assumed that a grader would operate for 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities. (BLM, 2003)
[b] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

Table A1.1.52: Alternatives A/B/C Fugitive Dust Emission Factors for Commuting Maintenance Vehicles

Emission Factors for Commuting Maintenance Vehicles Road Traffic

$$E\ [\text{lb/VMT}] = \frac{k(s/12)^{a}(W/3)^{d}}{(M/0.2)^{c}}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	BLM, 2003. Default value in EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98)
Control efficiency for watering (%) =	50	BLM, 2003. EPA, *Control of Open Fugitive Dust Sources* , Section 5.3.1 Watering of Unpaved Surfaces (1988)

Table A1.1.53: Alternatives A/B/C Fugitive Dust Emission Estimates for Commuting Maintenance Vehicles

Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT) [a]	Emissions (ton/proj.)	Em. Factor (lb/VMT) [a]	Emissions (ton/proj
Road Maintenance	Pickup Truck	7,000	6	1,455	8,729	0.63	2.8	0.09	0.4

[a] No dust control measures would be applied (BLM, 2003).

Table A1.1.54: Alternatives A/B/C Exhaust Emission Factors for Commuting Maintenance Vehicles

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).

[b] BLM, 2003. Including tire and brake wear emissions.

Source: EPA (1985), AP-42, Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II

Table A1.1.55: Alternatives A/B/C Exhaust Emission Estimates for Commuting Maintenance Vehicles

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (mi/day)	Total # of Operating Days	Total Miles Traveled	Emissions (ton/project)					
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC
Road Maintenance	Pickup Truck	LDGT2	6	1,455	8,729	0.01	0.001	0.001	0.001	0.11	0.01

$$\text{Emissions} = \frac{\text{emission factor g/mile*total distance in miles}}{\text{(453.6 g/lb)(2000lb/ton)}}$$

Table A1.1.56: Alternatives A/B/C Fugitive Emissions Factors for Long-Term Production Operations. Compressor Maintenance Vehicles Road Traffic.

Emission Factors for Compressor Maintenance Vehicles Road Traffic: Long-term Production

$$E\ [lb/VMT] = \frac{k(s/12)^a (W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
Control efficiency for watering (%) =	50	EPA, *Control of Open Fugitive Dust Sources*, Section 5.3.1 Watering of Unpaved Surfaces

Table A1.1.57: Alternatives A/B/C Fugitive Emissions Estimates for Long-Term Production Operations. Compressor Maintenance Vehicles Road Traffic.

Fugitive Dust Emissions Estimation for Compressor Maintenance Vehicles Road Traffic: Long-term Production

Activity	Vehicle Type	Av. Vehicle Weight (lb)	Compressor Station	# of Stations	# of Visits per Year	Total # of Round Trips	Round Trip Distance (mi)	Total Miles Traveled	PM_{10} Em. Factor (lb/VMT) [a]	PM_{10} Emissions (ton/proj.)	PM2.5 Em. Factor (lb/VMT) [d]	PM2.5 Emissions (ton/proj.
Maintenance Visits to Central Compressor Stations	Pickup Truck	7,000	Central Compressor Station	10	3	30	10	300	0.63	0.1	0.09	0.0
								Total		**0.1**		**0.0**

[a] No dust control measures would be applied (BLM, 2003, table APP_A21.xls).

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only, Pickup) = 24

Table A1.1.58: Alternatives A/B/C Exhaust Emissions Factors for Long-Term Production Operations. Compressor Maintenance Vehicles Road Traffic.

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic: Long-term Production

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).

[b] BLM, 2003. Including tire and brake wear emissions.

Source: EPA (1985), AP-42, Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II

Table A1.1.59: Alternatives A/B/C Exhaust Emissions Estimates for Long-Term Production Operations. Compressor Maintenance Vehicles Road Traffic.

Emissions Estimation for Road Traffic

Activity	Vehicle		Compressor Station	# of Stations	# of Visits per Year	Total # of Round Trips	Round Trip Distance (mi)	Total Miles Traveled	Emissions (ton/project)										
	Type	Class							NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Maintenance Visits to Compressor Stations	Pickup Truck	LDGT2	Central Compressor Station	10	2	20	10	200	0.000	0.0000	0.0000	0.0000	0.003	0.000	0	0	0	0	0
Total									**0.000**	**0.0000**	**0.0000**	**0.0000**	**0.00**	**0.000**					

Emissions per Station = $\frac{\text{emission factor g/mile*total distance in miles}}{\text{(453.6 g/lb)(2000lb/ton)}}$

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only, Pickup) = 24

Table A1.1.60: Alternatives A/B/C Natural Gas Well Condensate VOC Emissions

	VOC Losses					lb/hr/source					
Components	Working Loss (lbs)[a]	Breathing Loss (lbs)[a]	Total Emissions per tank (tons)	Total Number of Tanks	Total Tank Emissions (tpy)	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Gasoline (RVP8)	**1082.95**	**985**	**2068**	**88**	**91.07**	0.23626	0.0006	2.4E-05	0.00033	0.01046	0.00042

Meteorological Data used in Emissions Calculations: Grand Junction, Colorado (Avg Atmospheric Pressure = 12.27 psia)
[a] Calculated from Tanks 4.0

Table A1.1.61: Proposed Action Natural Gas Well Condensate Truck Loadout VOC and HAP Emissions

Natural Gas Well Condensate Truck Loadout VOC Emissions

Pollutant	Emission Factor (lbs/1,000 gallons)	Annual Condensate Volume bbl [a]	Condensate (1,000 gallons)	Total Emissions tpy	lb/hr/source				
					VOC	Benzene	Toluene	Ethyl-benzene	Hexane
VOCs	19.17	6,637,890	278,791	5	1.09335992	4.5E-06	3E-07	2.7E-06	8.5E-05

a Assume 50,000CFY conventional gas production, 9 bbl condensate per MMCF gas production

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per year that condensate tank has working and breathing losses (total emissions) = 8760

hours per year that condensate truck loadout occurs (used in calculation) = 8760

VOC and HAP emissions from Table B.2.8 of Jonah Technical Support Document; listed for Condensate Storage Tank

Table A1.2.1: Alternative D Assumptions

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	BLM 2003; Table APP_a21.xls	
TSP Emission Factor	1.2	EPA, *AP-42* , Volume I, Section 13.2.3 Heavy Construction	Tons TSP/acre-month
Conversion factor for TSP to PM-10	0.26	BLM 2003; Table APP_a21.xls	Percentage of TSP
Conversion factor for PM-10 to PM2.5	0.15	BLM 2003; Table APP_a21.xls	Percentage of PM-10
Total number of pads (year 30)	1227	BLM 2008	
Number wells to estimate construction emissions in yr 12	114	BLM 2008	
Compression per well	200	BLM 2008	
Average HP of the central compressor station	5,000	Pinedale 2005	
Total number of well head compressors	37	BLM 2008	

Well Emission Assumptions:

Emission factors derived from AP-42 or otherwise noted.

Gas compressors assumed to be BACT equipped.

Assume diesel fuel sulfur content of 15ppm for diesel engines.

Well condensate production assumed to be from wells with Best Available Control Technology (BACT).

Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10} for the following categories, heavy equipment traffic, natural gas compression, dehydrators, separators and flashing emissions.

Hazardous Air Pollutants (HAPS) assumed to be 10% of VOCs and formaldehyde added for gas compression emissions

For central compressors 30,000hp/ 1000 wells

For well head compressors, assume 200 Hp/compressor, installed on 30 of every 1,000 wells.

Assume natural gas heating value of 1,020 Btu/scf (BLM, 2003).

Assume that natural gas compressors would operate at full capacity.

86 is the total number of precipitation days for Kemmerer WY, Western Regional Climate Center.

Table A.1.2.62: Alternative D Natural Gas and Oil Pad Construction Fugitive Dust Assumptions

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C)of watering	0.5	BLM 2003; Table APP_a21.xls	
TSP Emission Factor	1.2	EPA, *AP-42* , Volume I, Section 13.2.3 Heavy Construction Operations (1/95)	Tons TSP/acre-month
Conversion factor for TSP to PM-10	0.26	BLM 2003; Table APP_a21.xls	Percentage of TSP
Conversion factor for PM-10 to PM2.5	0.15	BLM 2003; Table APP_a21.xls	Percentage of PM-10
Number of wells drilled	**114**	**BLM 2008**	
Total number of pads	**1227**	**BLM 2008**	
Number of wells to estimate construction emissions	**114**	**BLM 2008**	
Number of well head compressors in 2021	**37**	**BLM 2008**	
HP compression per well	**200**	**EOG Resources**	
HP of central compressor stations	**5,000**	**BLM 2008**	

Table A1.2.3: Alternative D, Natural Gas and Oil Pad Construction Fugitive Dust Emissions

Emissions Estimation for Construction Activities: Long-Term Development

Area Disturbed for NG Wells	Emission Estimation Basis	Disturbed Area (acre) [a]	Avg. Number of Days to Complete	Total # of Well Pads or Stations	Total Disturbed Area (acre)	Emissions								
						(lb/well pad or lb/stn)			(ton/project)			lb/hr/source		ton/year/source
						TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Drilling Roads, Producing Roads, Drilling Well Pad & Producing Well Pad, New Pipeline and Electric Line	per Well Pad	2.75	7	1,227	3,374	770	200	30	472	123	18	1.19	0	0
Central Compressor Station	per station	1.50	4	8	12	240	62	9	1	0	0	0.65	0	0
Totals					3,386	**Total**			**473**	**123**	**18**			

[a] From gross surface disturbance projections BLM

Note: number of compressor stations are for new construction

TSP= 1.2 tpy/acre-month x 3,374 acres x 7/30 days x 0.5 dust control efficiency = 472 tons

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per day = 24

Table A1.2.4: Alternative D Gas Analysis

Pinedale Frontier Formation Gas Analysis

Gas Component	Mol%	Mol%/100	Molecular Weight	Molecular Weight of each Component
N_2	1.2953	0.012953	28.01	0.363
Methane (C1)	83.3591	0.833591	16.04	13.371
CO_2	0.1265	0.001265	44.01	0.056
Ethane (C2)	8.7362	0.087362	30.07	2.627
Propane (C3)	4.1642	0.041642	44.10	1.836
I-Butane (iC4)	0.6661	0.006661	58.12	0.387
N-Butane (nC4)	0.9106	0.009106	58.12	0.529
I-pentane (iC5)	0.2129	0.002129	72.15	0.154
N-pentane (nC5)	0.1908	0.001908	72.15	0.138
Hexanes (C6)	0.1454	0.001454	84.18	0.122
Heptanes (C7)	0.1317	0.001317	100.20	0.132
Octanes (C8)	0.058	0.00058	114.23	0.066
Nonanes	0.0032	0.000032	114.23	0.004
TOTAL	**100**			**19.785**

MW = Mol%/100*MW

Methane (C1) = 0.833591*16.04 = 13.371

VOC = C_3^+ components = 3.368

VOC Weight Percent = 3.368/19.785*100 = 17.02%

BTU Value 1,189

Pinedale Frontier Formation Condensate Analysis

WELL NAME:	**Frontier Well**
COMPONENT	**MOL%**
H2S	0.0000
O2	0.0000
CO2	0.0000
N2	0.0000
C1	0.4064
C2	1.7056
C3	3.3635
IC4	2.2423
NC4	3.0113
IC5	3.8486
NC5	3.5648
Hexanes	14.1300
Heptanes	44.6335
Benzene	1.8256
Toluene	8.5229
E-Benzene	0.7922
Xylene	6.2070
n-C6	5.7245
2,2,4-Trimethylpentane	0.0219
Total	**100.000**

Table A1.2.5: Alternative D Exhaust Emissions Factors for Construction Equipment

Emission Factors for Construction Equipment						
Equipment	Emission Factors (g/hp-hr)					Equipment Category in AP-42 [a]
	NO_x	PM_{10}	SO_2	CO	VOCs	
Backhoe	8.81	0.81	0.86	2.71	0.97	Wheeled Loader
Dozer	7.81	0.69	0.85	2.15	0.75	Track-Type Tractor
Blade	7.14	0.63	0.87	1.54	0.36	Motor Grader
Trencher	11.01	0.90	0.93	4.60	1.01	Miscellaneous
Trackhoe	9.30	0.66	0.85	2.26	1.11	Track-Type Loader

[a] BLM, 2003, table APP_A21.

Source: EPA, *AP-42* , Volume II, Section II-7 Heavy-Duty Construction Equipment (9/85).

Table A1.2.6: Alternative D Natural Gas and Oil Well Pad Construction Exhaust Emissions

Construction Site	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Oper. Hrs per Day	# of Oper. Days per Well Pad or per Station	# of Oper. Hrs per Well Pad or per Station	# of Well Pads or Stations	Emissions (lb/well pad, lb/station, or lb/project)					Emissions (ton/equipment type)					Emissions (ton/construction site)					Emissions lb/hour/source			Emissions ton/year/source	
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10} [a]	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	PM_{10}	SO_2	CO	NO_x	SO_2
Drilling Roads	Blade	100	1	80	10	3	30	114	38	3.3	4.6	8	1.9	2	0.2	0.3	0.5	0.1	4.1	0.4	0.5	1.1	0.3	0.1	0	0.3	0	0.0
	Backhoe	80	1	75	10	3	30	114	35	3.2	3.4	11	3.8	2	0.2	0.2	0.6	0.2						0.1	0	0.4	0	0.0
Producing Roads	Blade	100	1	80	10	3	30	114	38	3.3	4.6	8	1.9	2	0.2	0.3	0.5	0.1	4.1	0.4	0.5	1.1	0.3	0.1	0	0.3	0	0.0
	Backhoe	80	1	75	10	3	30	114	35	3.2	3.4	11	3.8	2	0.2	0.2	0.6	0.2						0.1	0	0.4	0	0.0
Drilling Well Pad	Backhoe	80	1	75	10	2	20	114	23	2.1	2.3	7	2.6	1	0.1	0.1	0	0.1	1.3	0.1	0.1	0.4	0.1	0.1	0	0.4	0	0.0
Producing Well Pad	Backhoe	80	1	75	10	2	20	114	23	2.1	2.3	7	2.6	1	0.1	0.1	0	0.1	1.3	0.1	0.1	0.4	0.1	0.1	0	0.4	0	0.0
New Pipeline	Blade	100	1	80	10	1	10	114	13	1.1	1.5	3	0.6	1	0.1	0.1	0.2	0.0	3	0.3	0.3	1	0.3	0.1	0	0.3	0	0.0
	Trencher	175	1	80	10	1	10	114	34	2.8	2.9	14	3.1	2	0	0	1	0						0.3	0	1.4	0	0
	Backhoe	80	1	75	10	1	10	114	12	1.1	1.1	4	1.3	1	0.1	0.1	0.2	0.1						0.1	0	0.4	0	0.0
Well Head Compressors	Dozer	350	1	80	8	2	16	37	77	6.8	8.4	21	7.4	1	0.13	0.16	0.4	0.1	2.2	0.2	0.2	0.6	0.2	0.4	1	1.3	0	0.00
	Backhoe	80	2	80	8	2	16	37	40	3.7	3.9	12	4.4	1	0.07	0.07	0.23	0.08						0.2	0	0.8	0	0.00
Central Compressor Station	Dozer	350	1	80	8	2	16	8	77	6.8	8.4	21	7.4	0	0.03	0.03	0.1	0.0	0.5	0.0	0.0	0.1	0.0	0.4	1	1.3	0	0.00
	Backhoe	80	2	80	8	2	16	8	40	3.7	3.9	12	4.4	0	0.01	0.02	0.05	0.02						0.2	0	0.8	0	0.00
																		Subtotal	**17**	**1.5**	**1.8**	**4.9**	**1.5**					

Table A1.2.7: Alternative D Exhaust Emission Factors for Industrial Engines

Emission Factors for Industrial Engines (Tier IV)

Emission Source	Fuel Type	Emission Factors					
		Unit	NO_x	PM_{10}	SO_x	CO	VOC
Industrial Engine [a]	Diesel	lb/hp-hr	6.61E-04	3.30E-05	5.10E-05	5.73E-03	2.20E-04
Industrial Engine [b]	Diesel	lb/hp-hr	2.40E-02	5.73E-04	4.05E-04	5.50E-03	7.05E-04

[a] BLM 2008 from memo

[b] EPA, *AP-42* , Volume I, Section 3.4 Large Stationary Diesel and all Stationary Dual Fuel Engines (10/96).

Table A1.2.8: Alternative D Emission Estimates for Industrial Engines

Emissions Estimation for Industrial Engines

Construction Site Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Operating Hours per Day	# of Operating Days per Well	# of Operating Hours per Well	# of Wells	Emissions																			
									(lb/well)					(ton/equipment type)					(ton/project activity)					lb/hr/source			ton/yr/source	
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10} [a]	SO_x	CO	VOC	NO_x	PM_{10} [a]	SO_x	CO	VOC	PM_{10} [a]	SO_x	CO	NO_x	SO_x
Rig-up, Drilling, and Rig-down	Main Deck	2,100	1	42	24	25	600	114	350	17	27	2,911	117	20	1	2	166	7	23	1.1	1.8	191	8	0	0	5	0	0
	Auxiliary Pump	600	1	42	8	25	200	114	33	2	3	277	11	2	0	0	16	1						0	0	1	0	0
	Generator	150	1	75	24	10	240	114	18	1	1	155	6	1	0	0	9	0						0	0	1	0	0
Well Completion & Testing	Main Deck	2100	1	42	24	5	120	114	70	3	5	606	23	4	0	0	35	1	5	0	0	41	2	0	0	5	0	0
	Auxiliary Pump	225	1	42	24	4	96	114	6	0	0	52	2	0	0	0	3	0						0	0	1	0	0
	Power Swivel	150	1	75	24	4	96	114	7	0	1	62	2	0	0	0	4	0						0	0	1	0	0
									4.84E+02	**24**	**37**	**4,063**					**Subtotal**		**28**	**1**	**2**	**232**	**9**					

Table A1.2.9: Alternative D Field Generator Emission Factors

Emission Factors for Field Generators (Tier II)

Emission Source	Fuel Type	Emission Factors					
		Unit	NO_x	PM_{10}	SO_x	CO	VOC
Industrial Engine [a]	Diesel	g/hp-hr	4.90E+00	2.20E-01	9.30E-01	3.70E+00	4.90E+00
Industrial Engine	Diesel	lbs/hp-hr	1.08E-02	4.80E-04	2.05E-03	8.20E-03	1.08E-02

[a] From USA - Nonroad Diesel Engines Tier 2 Emission Standards
Emission factors for a < 600 hp generator, (NOx & VOC = 4.9 g/bhp-hr)

Table A1.2.10: Alternative D Temporary Exhaust Emissions Estimates for Field Generators

Temporary Emissions Estimation for Field Generators

Construction Site Activity	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	# of Operating Hours per Day	# of Operating Days per Well	# of Operating Hours per Well	# of Wells	Emissions														
									(lb/well)					(ton/equipment type)					lb/hr/source			ton/yr/source	
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10} [a]	SO_x	CO	VOC	PM_{10}	SO_2	CO	NO_x	SO_2
Field Generators	Field Generators for Pumps & Lighting	100	1	75	12	8	96	114	78	3	15	59	78	4	0	1	3	4	0	0	1	0	0
													TOTALS	4	0.2	1	3	4					

Table A1.2.11: Alternative D Estimate of Emission Factors for Emissions From Well Construction Flaring

Emission Factors for Flaring

Unit	NO_x	PM_{10}	SO_2	CO
lb/MMscf	76.0	7.6	0.6	413.3
lb/MMBtu	6.80E-02	6.80E-03	5.37E-04	3.70E-01

Emission factors for NOx & CO Source: EPA, *AP-42* , Volume I, Section 13.5 Industrial Flares

Emission factors for PM10 & SO2 from EPA, AP-42, Volume I, Section 1.4 Natural Gas Combustion

Table A1.2.12: Alternative D Emissions From Well Completion Flaring

Well Completion Flaring	Gas Production Estimate (MMSCF) per day	# of Days of Flaring	Av. Heat Content of Gas btu/scf	# of Wells	Emissions												
					(lb/well)				(tons)				lb/hr/source			ton/yr/source	
					NO_x	PM_{10}	SO_2	CO	NO_x	PM_{10} [a]	SO_x	CO	PM_{10}	SO_2	CO	NO_x	SO_2
Flaring	1	2	1020	114	139	15.2	1.2	755	8	1	0.1	43	0.3	0.0	15.7	0	0
								TOTALS	**8**	**1**	**0.1**	**43**					

Emissions = EVH where E= emission factor; V= gas volume; H= heat content
NOx= 0.068lbs/MMBtu*1.0 MMSCFD*1020 Btu/scf = 69.5 lbs per well* 2 days = 139 lbs per well
PM10 & SO2 Emissions = EV where E= emission factor; V= gas volume
PM10 = 7.6 lbs/MMSCF*1.0 MMSCFD = 7.6 lbs/well*2days = 15.2 lbs per well

<u>Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation</u>
hours per day = 24

Table A1.2.13: Alternative D VOC Emissions from Well Completion Flaring

VOC Emissions Well Flaring

Well Completion Flaring	VOC Emission Factor lbs per well	# of Wells	VOC Emissions tons
Flaring	8,863	114	504

Assume average VOC content 17 %
Average Mole Weight 19.785
Gas production rate of 1.0 MMSCF per well per day
Assume 2 days of flaring

Flare Gas wt= 2.0 MMSCF*1,000,00scf/MMSCF*19.785 lbs/lbs-mole / 379.49scf/mole

VOC Emissions= 104,272 lbs/well*0.17VOC wt%*0.5 efficiency destruction = 8,863 lbs/well

HAPs are estimated at 10% of VOC amounts and are shown on total spread sheets
Assume same gas production rate for short term and long term new constructed wells of 1.0 MMSCFD

Table A1.2.14: Alternative D Natural Gas and Oil Well Pad Construction Wind Erosion

Emission Factor: 0.3733 llb/hr/100m^2

Control Efficiency: 50%

Based on AP-42 Chapter 13.2.5 (EPA 2004), Industrial Wind Erosion using Jonah Field, Wyoming meterological data.

Disturbed Area:

Well Pad Construction:	2.75 acres	11128.87 m^2
Central Compressor Construction:	1.50 acres	6070.29 m^2
Access Road Construction:	3.00 acres	12140.58 m^2
Pipeline Construction:	0.50 acres	2023.43 m^2

Source Parameters
147 1-km area sources
sigma z=2.33 m

PM_{10} Emission Calculations:

	PM_{10} Emission Factor (llb/hr/100m^2)	$PM_{2.5}$ Emission Factor (llb/hr/100m^2)	Area 100 m^2	Control Efficiency (%)	PM_{10} Emissions (lb/hr)	$PM_{2.5}$ Emissions (lb/hr)	PM_{10} Emissions (g/sec)	$PM_{2.5}$ Emissions (g/sec)
Well Pad Construction:	0.3733	0.1493	111.29	50	20.77	8.31	2.62	1.05
Central Compressor Construction	0.3733	0.1493	60.70	50	11.33	4.53	1.43	0.57
Resource Road Construction:	0.3733	0.1493	121.41	50	22.66	9.06	2.86	1.14
Pipeline Construction:	0.3733	0.1493	20.23	50	3.78	1.51	0.48	0.19
Total:					**58.54**	**23.41**	**7.38**	**2.95**

Table A1.2.15: Alternative D Fugitive Dust Emissions from Commuting Vehicles. Emission Factors for Road Traffic.

Emission Factors for Road Traffic

$$E\ (\text{lb/VMT}) = \frac{k\ (s/12)^a\ (W/3)^d}{(M/0.2)^c}$$

Parameter	**PM_{10}**	**$PM_{2.5}$**
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98)

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98)
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	0.2	default value in EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98)
CE = control efficiency for watering (%)	50	EPA, *Control of Open Fugitive Dust Sources* , Section 5.3.1 Watering of Unpaved Surfaces (1988)

Table A1.2.16: Alternative D Fugitive Dust Emissions Estimates for Natural Gas and Oil Well Pad Construction Road Traffic

Emissions Estimation for Road Traffic

Construction Site Destination	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station	Miles Traveled per Well Pad or per Station	Total # of Well Pads or Stations	PM_{10}				$PM_{2.5}$				Emissions		
							Controlled Em. Factor (lb/VMT)	Emissions			Controlled Em. Factor (lb/VMT)	Emissions			lb/hr/source		ton/year/ source
								(lb/well pad, lb/stn, or lb/proj.)	(ton/veh. type)	(ton/const. site)		(lb/well pad, lb/stn, or lb/proj.)	(ton/veh. type)	(ton/const. site)	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Drilling Roads	Semi Trucks	60,000	6	2	12	1,227	1.21	15	9	9	0.18	2.2	1.3	1.3	0	0	0
Producing Roads	Semi Trucks	60,000	6	2	12	1,227	1.21	15	9	9	0.18	2.2	1.3	1.3	0	0	0
Drilling Well Pad	Haul Trucks	45,000	6	2	12	1,227	1.05	13	8	11	0.16	1.9	1.2	1.6	0	0	0
	Pickup Trucks	7,000	6	2	12	1,227	0.41	5.0	3		0.06	0.7	0.5		0	0	0
Producing Well Pad	Haul Trucks	45,000	6	2	12	1,227	1.05	13	8	11	0.16	1.9	1.2	1.6	0	0	0
	Pickup Trucks	7,000	6	2	12	1,227	0.41	5.0	3		0.06	0.7	0.5		0	0	0
New Pipeline	Haul Trucks	45,000	6	2	12	1,227	1.05	13	8	11	0.16	1.9	1.2	2	0	0	0
	Pickup Trucks	7,000	6	2	12	1,227	0.41	5	3		0.06	0.7	0.5		0	0	0
Electric Line	Haul Trucks	45,000	6	2	12	1,227	1.05	12.6	8	11	0.16	1.9	1.2	1.6	0	0	0
	Pickup Trucks	7,000	6	2	12	1,227	0.41	5.0	3		0.06	0.7	0.5		0	0	0
Well Head Compressors	Semi Trucks	60,000	6	2	12	37	1.21	15	0.3	1	0.18	2	0.0	0	0	0	0
	Haul Trucks	45,000	6	2	12	37	1.05	13	0		0.16	2	0.0		0	0	0
	Pickup Trucks	7,000	6	2	12	37	0.41	5	0		0.06	1	0.0		0	0	0
Central Compressor Station	Semi Trucks	60,000	6	2	12	8	1.21	15	0.1	0	0.18	2	0.0	0	0	0	0
	Haul Trucks	45,000	6	2	12	8	1.05	13	0		0.16	2	0.0		0	0	0
	Pickup Trucks	7,000	6	2	12	8	0.41	5	0		0.06	1	0.0		0	0	0
								Subtotal		**62**				**9**			

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation
hours per day = 10
days per source = 21

Table A1.2.17: Alternative D Fugitive Dust Emissions Estimates for Natural Gas and Oil Well Construction Road Traffic

Emissions Estimation for Road Traffic

Construction Site Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station [a]	Miles Traveled per Well Pad or per Station	Total # of Wells or Stations	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lb/well)	PM_{10} Emissions (ton/veh. type)	PM_{10} Emissions (ton/proj. activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lb/well)	$PM_{2.5}$ Emissions (ton/veh. type)	$PM_{2.5}$ Emissions (ton/proj. activity)	Emissions lb/hr/source PM_{10}	Emissions lb/hr/source $PM_{2.5}$	Emissions ton/year/source $PM_{2.5}$
	Semi Rig Transport & Drill Rig	80,000	6	5	30	1,227	1.40	42	26		0.21	6.3	3.9		0	0	0
	Fuel Haul Truck	50,000	6	5	30	1,227	1.10	33	20.3		0.17	5.0	3.0		0	0	0
	Mud Haul Truck, Water Hauling	60,000	6	5	30	1,227	1.21	36	22		0.18	5	3.3		0	0	0
	Rig Crew	7,000	6	5	30	1,227	0.41	12	7.6		0.06	1.9	1.1		0	0	0
	Rig Mechanics	12,000	6	5	30	1,227	0.54	16	10.0		0.08	2.4	1.5		0	0	0
Rig-up, Drilling, and Rig-down	Co. Supervisor	7,000	6	5	30	1,227	0.41	12	8	143	0.06	1.9	1.1	21	0	0	0
	Tool Pusher	7,000	6	5	30	1,227	0.41	12	7.6		0.06	1.9	1.1		0	0	0
	Mud Logger	7,000	6	5	30	1,227	0.41	12	7.6		0.06	1.9	1.1		0	0	0
	Mud Engineer	7,000	6	5	30	1,227	0.41	12	7.6		0.06	1.9	1.1		0	0	0
	Logger, Engr Truck	45,000	6	5	30	1,227	1.05	31.4	19.3		0.16	4.7	2.9		0	0	0
	Drill Bit Delivery	7,000	6	5	30	1,227	0.41	12	8		0.06	1.9	1.1		0	0	0
	Semi Casing Haulers	60,000	6	2	12	1,227	1.21	14.5	9		0.18	2.2	1.3		0	0	0
	Semi Completion, Unit Rig	120,000	6	8	48	1,227	1.71	82	50.4		0.26	12.3	7.6		0	0	0
	Semi Fracing Blender	85,000	6	2	12	1,227	1.44	17	10.6		0.22	2.6	1.6		0	0	0
	Semi Pumping Tank Battery	80,000	6	2	12	1,227	1.40	17	10.3		0.21	2.5	1.5		0	0	0
	Tubing Truck	60,000	6	2	12	1,227	1.21	14.5	8.9		0.18	2.2	1.3		0	0	0
	Haul Cementer, Pump Truck	85,000	6	2	12	1,227	1.44	17	10.6		0.22	2.6	1.6		0	0	0
	Haul Cementer, Cement Truck	60,000	6	8	48	1,227	1.21	58	35.6		0.18	8.7	5.3		0	0	0
	Haul Completion, Equip Truck	45,000	6	2	12	1,227	1.05	12.6	7.7		0.16	1.9	1.2		0	0	0
	Haul Service Tools	7,000	6	2	12	1,227	0.41	5.0	3.0		0.06	0.7	0.5		0	0	0
	Haul Perforators Logging Truck	45,000	6	2	12	1,227	1.05	12.6	7.7		0.16	1.9	1.2		0	0	0
	Haul Anchor Installation	40,000	6	2	12	1,227	0.99	11.9	7.3		0.15	1.8	1.1		0	0	0
	Haul Anchor Testing	12,000	6	2	12	1,227	0.54	6.5	4.0		0.08	1.0	0.6		0	0	0
	Haul Fracing Tank	40,000	6	2	12	1,227	0.99	11.9	7.3		0.15	1.8	1.1		0	0	0
Well Completion & Testing	Haul Fracing Pump	85,000	6	2	12	1,227	1.44	17.3	10.6		0.22	2.6	1.6		0	0	0
	Haul Fracing Chemical	45,000	6	2	12	1,227	1.05	12.6	7.7		0.16	1.9	1.2		0	0	0
	Haul Fracing Sand	60,000	6	2	12	1,227	1.21	14.5	8.9		0.18	2.2	1.3		0	0	0
	Haul Fracing Other	85,000	6	2	12	1,227	1.44	17.3	10.6	329	0.22	2.6	1.6	49	0	0	0
	Haul Welders	12,000	6	2	12	1,227	0.54	6.5	4.0		0.08	1.0	0.6		0	0	0
	Haul Water Truck	60,000	6	8	48	1,227	1.21	58	36		0.18	9	5.3		0	0	0
	Pickup Cementer, Engineer	7,000	6	2	12	1,227	0.41	5.0	3.0		0.06	0.7	0.5		0	0	0
	Pickup Chasing Crew	10,000	6	2	12	1,227	0.49	5.9	3.6		0.07	0.9	0.5		0	0	0
	Pickup Completion Crew	10,000	6	8	48	1,227	0.49	23.7	14.5		0.07	3.6	2.2		0	0	0
	Pickup Completion Pusher	7,000	6	8	48	1,227	0.41	19.8	12.2		0.06	3.0	1.8		0	0	0
	Pickup Perforators Engineer	7,000	6	8	48	1,227	0.41	19.8	12.2		0.06	3.0	1.8		0	0	0
	Pickup Fracing Engineer	10,000	6	2	12	1,227	0.49	5.9	3.6		0.07	0.9	0.5		0	0	0
	Pickup Co. Supervisor	7,000	6	8	48	1,227	0.41	19.8	12.2		0.06	3.0	1.8		0	0	0
	Miscellaneous Supplies	7,000	6	8	48	1,227	0.41	19.8	12.2		0.06	3.0	1.8		0	0	0
	Pickup Roustabout Crew	12,000	6	2	12	1,227	0.54	6	4.0		0.08	1.0	0.6		0	0	0
	Semi Trucks	60,000	6	2	12	91	1.21	15	0.7		0.18	2	0.1		0	0	0
Well Head Compressors	Haul Trucks	45,000	6	2	12	91	1.05	13	1		0.16	2	0.1		0	0	0
	Pickup Trucks	7,000	6	2	12	91	0.41	5	0		0.06	1	0.0		0	0	0
	Semi Trucks	60,000	6	2	12	8	1.21	15	0.1		0.18	2	0.0		0	0	0
Central Compressor Staton	Haul Trucks	45,000	6	2	12	8	1.05	13	0		0.16	2	0.0		0	0	0
	Pickup Trucks	7,000	6	2	12	8	0.41	5	0		0.06	1	0.0		0	0	0

Table A1.2.18: Alternative D Exhaust Emission Factors for Commuting Vehicles

Emission Factors for Road Traffic

Vehicle		Emission Factors (g/mi)					
Type	Class	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	LDGT2	1.01	0.10	0.08	0.11	11.64	0.75
Heavy-Duty Diesel Truck	HDDV	8.13	1.96	1.81	1.63	17.09	4.83

[a] From BLM, 2003, APP_A21, table 1.1.2.2, estimated using EPA PART5 Model (1995)
[b] Including tire and brake wear emissions.
Source: EPA, *AP-42* , Volume II, Appendix H-117, Table 3.1A.2 Light Duty Gasoline Powered Trucks II and
Appendix H-259, Table 7.1.2 Heavy Duty Diesel Powered Vehicles (High Altitude; Model Year 1991-1997; 50,000 mileage) (6/30/95).

Table A1.2.19: Alternative D Exhaust Emissions Estimates for Natural Gas and Oil Well Construction Road Traffic

Emissions Estimation for Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station	Miles Traveled per Well Pad or per Station	Total # of Well Pads or Stations	Emissions (lb/well pad, lb/station, or lb/project) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC
Drilling Roads	Semi Trucks	HDDV	6	2	12	1,227	0.22	0.05	0.05	0.04	0.45	0.13
Producing Roads	Semi Trucks	HDDV	6	2	12	1,227	0.22	0.05	0.05	0.04	0.45	0.13
Drilling Well Pad	Haul Trucks	HDDV	6	2	12	1,227	0.22	0.05	0.05	0.04	0.45	0.13
	Pickup Trucks	LDGT2	6	2	12	1,227	0.03	0.003	0.002	0.003	0.31	0.02
Producing Well Pad	Haul Trucks	HDDV	6	2	12	1,227	0.22	0.05	0.05	0.04	0.45	0.13
	Pickup Trucks	LDGT2	6	2	12	1,227	0.03	0.003	0.002	0.003	0.31	0.02
New Pipeline	Haul Trucks	HDDV	6	2	12	1,227	0.22	0.05	0.05	0.04	0.45	0.13
	Pickup Trucks	LDGT2	6	2	12	1,227	0.03	0.00	0.00	0.00	0.31	0.02
Electric Line	Haul Trucks	HDDV	6	2	12	1,227	0.22	0.05	0.05	0.04	0.45	0.13
	Pickup Trucks	LDGT2	6	2	12	1,227	0.03	0.003	0.002	0.003	0.31	0.02
Central Compressor Station	Semi Trucks	HDDV	6	2	12	8	0.22	0.05	0.05	0.04	0.45	0.13
	Haul Trucks	HDDV	6	2	12	8	0.22	0.05	0.05	0.04	0.45	0.13
	Pickup Trucks	LDGT2	6	2	12	8	0.03	0.00	0.00	0.00	0.31	0.02

Construction Site Destination	Vehicle Type	(ton/vehicle type) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	(ton/construction site) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	lb/hr/source PM_{10}	$PM_{2.5}$	SO_2	CO	ton/year/source NO_x	$PM_{2.5}$	SO_2
Drilling Roads	Semi Trucks	0.1	0.03	0.03	0.03	0.3	0.1	0.1	0.03	0.03	0.03	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Producing Roads	Semi Trucks	0.1	0.03	0.03	0.03	0.3	0.1	0.1	0.03	0.03	0.03	0.3	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Drilling Well Pad	Haul Trucks	0.1	0.03	0.03	0.03	0.3	0.1	0.1	0.03	0.03	0.03	0.5	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	0.0	0.002	0.001	0.002	0.2	0.01							0.00	0.000	0.000	0.001	0.00	0.00	0.0
Producing Well Pad	Haul Trucks	0.1	0.03	0.03	0.03	0.3	0.1	0.1	0.03	0.03	0.03	0.5	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	0.0	0.002	0.001	0.002	0.2	0.01							0.00	0.000	0.000	0.001	0.00	0.00	0.0
New Pipeline	Haul Trucks	0.1	0.0	0.0	0.03	0.3	0.1	0.1	0.0	0.0	0.0	0.5	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	0.0	0.002	0.001	0.002	0.2	0.01							0.00	0.00	0.00	0.00	0.00	0.00	0.0
Electric Line	Haul Trucks	0.1	0.03	0.03	0.03	0.3	0.08	0.1	0.03	0.03	0.03	0.5	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	0.0	0.002	0.001	0.002	0.2	0.01							0.00	0.000	0.000	0.001	0.00	0.00	0.0
Central Compressor Station	Semi Trucks	0.0	0.000	0.000	0.000	0.00	0.001	0.0	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Trucks	0.0	0.000	0.000	0.000	0.00	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Trucks	0.0	0.000	0.000	0.000	0.0	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
							Subtotal	**0.9**	**0.2**	**0.2**	**0.2**	**2.4**	**0.5**							

<u>Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation</u>

hours per day = 10

days per source = 21

Table A1.2.20: Alternative D Exhaust Emissions Estimates for Natural Gas and Oil Well Construction Road Traffic

Emissions Estimation for Road Traffic

Construction Site Activity	Vehicle Type	Vehicle Class	Round Trip Distance (mi)	# of Round Trips per Well Pad or	Miles Traveled per Well or per Station	Total # of Wells or Stations	Emissions (lb/well)						(ton/vehicle type)						(ton/project activity)						lb/hr/source				ton/year/source		
							NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	PM_{10}	$PM_{2.5}$	SO_2	CO	NO_x	$PM_{2.5}$	SO_2
Rig-up, Drilling, and Rig-down	Semi Rig Transport	HDDV	6	12	72	114	1.29	0.31	0.29	0.26	2.71	0.77	0.1	0.02	0.02	0.01	0.2	0.04							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Fuel Haul Truck	HDDV	6	12	72	114	1.29	0.31	0.29	0.26	2.71	0.77	0.1	0.02	0.02	0.01	0.2	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Mud Haul Truck, Water	HDDV	6	12	72	114	1.29	0.31	0.29	0.26	2.71	0.77	0.1	0.0	0.0	0.0	0.2	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Rig Crew	LDGT2	6	12	72	114	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.001	0.001	0.001	0.1	0.01							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Rig Mechanics	HDDV	6	2	12	114	0.22	0.05	0.05	0.04	0.45	0.13	0.0	0.003	0.003	0.002	0.0	0.01							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Co. Supervisor	LDGT2	6	12	72	114	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.00	0.00	0.00	0.1	0.01	0.4	0.1	0.1	0.1	1.3	0.2	0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Tool Pusher	LDGT2	6	12	72	114	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.0	0.0	0.0	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Mud Logger	LDGT2	6	12	72	114	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.0	0.0	0.0	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Mud Engineer	LDGT2	6	12	72	114	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.0	0.0	0.0	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Logger, Engr Truck	HDDV	6	12	72	114	1.29	0.31	0.29	0.26	2.71	0.77	0.1	0.0	0.0	0.0	0.2	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Drill Bit Delivery	LDGT2	6	12	72	114	0.16	0.02	0.01	0.02	1.85	0.12	0.0	0.00	0.00	0.00	0.1	0.01							0.00	0.00	0.00	0.01	0.00	0.00	0.0
Well Completion & Testing	Semi Casing Haulers	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Semi Completion, Unit Rig	HDDV	6	20	120	114	2.15	0.52	0.48	0.43	4.52	1.28	0.1	0.03	0.03	0.02	0.3	0.07							0.00	0.00	0.00	0.02	0.00	0.00	0.0
	Semi Fracing Blender	HDDV	6	4	24	114	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.00	0.1	0.01							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Semi Pumping Tank Battery	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Tubing Truck	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Cementer, Pump Truck	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Cementer, Cement Truck	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Completion Equip Truck	HDDV	6	20	120	114	2.15	0.52	0.48	0.43	4.52	1.28	0.1	0.03	0.03	0.02	0.3	0.07							0.00	0.00	0.00	0.02	0.00	0.00	0.0
	Haul Service Tools	LDGT2	6	6	36	114	0.08	0.01	0.01	0.01	0.92	0.06	0.0	0.00	0.00	0.00	0.1	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Perforators Logging Truck	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Anchor Installation	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Anchor Testing	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.02							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Haul Fracing Tank	HDDV	6	4	24	114	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.00	0.1	0.01							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Fracing Pump	HDDV	6	4	24	114	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.00	0.1	0.01							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Fracing Chemical	HDDV	6	4	24	114	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.00	0.1	0.01							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Fracing Sand	HDDV	6	4	24	114	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.00	0.1	0.01							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Fracing Other	HDDV	6	4	24	114	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.00	0.1	0.01	1.2	0.3	0.3	0.2	3.2	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Welders	HDDV	6	4	24	114	0.43	0.10	0.10	0.09	0.90	0.26	0.0	0.01	0.01	0.00	0.1	0.01							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Haul Water Truck	HDDV	6	20	120	114	2.15	0.52	0.48	0.43	4.52	1.28	0.1	0.03	0.03	0.02	0.3	0.07							0.00	0.00	0.00	0.02	0.00	0.00	0.0
	Pickup Cementer, Engineer	LDGT2	6	6	36	114	0.08	0.01	0.01	0.01	0.92	0.06	0.0	0.00	0.00	0.00	0.1	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Pickup Chasing Crew	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.0	0.0	0.0	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Pickup Completion Crew	HDDV	6	20	120	114	2.15	0.52	0.48	0.43	4.52	1.28	0.1	0.0	0.0	0.0	0.3	0.1							0.00	0.00	0.00	0.02	0.00	0.00	0.0
	Pickup Completion Pusher	LDGT2	6	20	120	114	0.27	0.026	0.020	0.030	3.08	0.20	0.02	0.001	0.001	0.002	0.2	0.01							0.00	0.000	0.000	0.015	0.00	0.00	0.00
	Pickup Perforations Engineer	LDGT2	6	20	120	114	0.27	0.026	0.020	0.030	3.08	0.20	0.02	0.001	0.001	0.002	0.2	0.01							0.00	0.000	0.000	0.015	0.00	0.00	0.00
	Pickup Fracing Engineer	HDDV	6	4	24	114	0.43	0.104	0.096	0.086	0.90	0.26	0.02	0.006	0.005	0.005	0.1	0.01							0.00	0.000	0.000	0.004	0.00	0.00	0.00
	Pickup Co. Supervisor	LDGT2	6	20	120	114	0.27	0.026	0.020	0.030	3.08	0.20	0.02	0.001	0.001	0.002	0.2	0.01							0.00	0.000	0.000	0.015	0.00	0.00	0.00
	Pickup Misc Supplies	LDGT2	6	20	120	114	0.27	0.026	0.020	0.030	3.08	0.20	0.02	0.001	0.001	0.002	0.2	0.01							0.00	0.000	0.000	0.015	0.00	0.00	0.00
	Pickup Roustabout Crew	HDDV	6	6	36	114	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.01	0.01	0.01	0.1	0.0							0.00	0.00	0.00	0.01	0.00	0.00	0.0
Well Head Compressors	Semi Trucks	HDDV	6	6	150	37	2.69	0.65	0.60	0.54	5.65	1.60	0.0	0.012	0.011	0.010	0.10	0.030							0.00	0.00	0.00	0.03	0.00	0.00	0.0
	Haul Trucks	HDDV	6	6	36	37	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.003	0.003	0.002	0.03	0.01							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Pickup Trucks	LDGT2	6	6	36	37	0.08	0.01	0.01	0.01	0.92	0.06	0.0	0.000	0.000	0.000	0.0	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
Central Compressor Station	Semi Trucks	HDDV	6	6	150	8	2.69	0.65	0.60	0.54	5.65	1.60	0.0	0.003	0.002	0.002	0.02	0.006							0.00	0.00	0.00	0.03	0.00	0.00	0.0
	Haul Trucks	HDDV	6	6	36	8	0.65	0.16	0.14	0.13	1.36	0.38	0.0	0.001	0.001	0.001	0.01	0.00							0.00	0.00	0.00	0.01	0.00	0.00	0.0
	Pickup Trucks	LDGT2	6	6	36	8	0.08	0.01	0.01	0.01	0.92	0.06	0.0	0.000	0.000	0.000	0.0	0.00							0.00	0.00	0.00	0.00	0.00	0.00	0.0
																		Subtotal	**1.6**	**0.4**	**0.3**	**0.3**	**4**	**0.8**							

Table A1.2.21: Alternative D Emission Factors and Estimates for Central Compressor Stations

Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Emission Factors (g/hp-hr) [a,d]						
			NOx [a,]	PM_{10} [b,c]	SO_2 [b]	CO	VOC	HCHO	Formaldehyde
Central Compressor Station	Rich Burn	5,000	1.00	5.2E-03	2.0E-03	2.00	1.00	0.07	0.08

[a] From State of Wyoming AQD BACT for all except Formaldehyde
[b] From BLM, 2003. Source: EPA, *AP-42*, Volume I, Section 3.2 Natural Gas-Fired Reciprocating Engines, Table 3.2-2 & 3.2-3 (7/00).
[c] From BLM, 2003. Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}.
[d] Formaldehyde emission factor is from Table B.2.10 of Johah Infill Drilling Project Technical Support Document, which references the Bird Canyon Permit

Emissions Estimation for Compressors

Type of Compressors	Total # of Operating Station-Year	Operating Hours per Year	Total Emissions (ton/year)							Emissions (lb/hr)				
			NOx	PM_{10}	SO_2	CO	VOC	HCHO	Formaldehyde	PM_{10}	SO_2	CO	VOC	Formal-dehyde
Central Compressor Station	8	8,760	386	2	1	772	386	27	4	0	0	176	88	0.88
		Total	**386**	**2**	**1**	**772**	**386**	**27**						

Emissions per Compressor = emission factor g/hp-hr*compressor engine hp rating*(453.6g/lb)

NOX Emissions= (1.0 g/hp-hr*5,000 hp)/453.6g/lb = 110.23 lb per hour*8760 hours*8 stations/2000lb per ton = 386 tpy

Table A1.2.22: Alternative D Emission Factors for Well Head Compressors

Emission Factors for Natural Gas-Fired Compressors

Compressor			Make	Model	Capacity (hp)	Emission Factors (g/hp-hr)						
						NOx [a, d]	PM_{10} [b,c]	SO_2 [b]	CO	VOC	HCHO	CH_2O [e]
Well Head Compressors	Lean Burn	50%	Caterpillar	G3516LE	200	1.00	6.6E-02	2.0E-03	0.50	1.0E+00	0.07	0.08
	Rich Burn	50%	Waukesha	7044GSI	200	1.00	6.6E-02	2.0E-03	2.00	1.0E+00	0.05	0.08

[a] BACT
[b] From BLM Rawlins RMP, 2005. Source: EPA, *AP-42* , Volume I, Section 3.2 Natural Gas-Fired Reciprocating Engines, Table 3.2-2 & 3.2-3 (7/00).
[c] From BLM Rawlins RMP, 2005. Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}.
[d] Equipped with oxidizing catalyst and from Caterpillar gas engine technical data
[e] Formaldehyde emission factor is from Table B.2.10 of Johah Infill Drilling Project Technical Support Document, which references the Bird Canyon Permit

Table A1.2.23: Alternative D Emissions Estimates for Well Head Compressors

Emissions Estimation for Compressors

Type of Compressors	Total # of Operating Station-Year	Operating Hours per Year	Total Emissions (ton/year)						
			NOx	PM_{10}	SO_2	CO	VOC	HCHO*	CH_2O
Well Head Compressors	37	8,760	71.46	4.72	0.14	89.32	71.46	4.29	5.72
		Total	**71.46**	**4.72**	**0.14**	**89.32**	**71.46**	**4.29**	**5.72**

Total conventional well production based on 50,000 CF/day/well
*HCHO= formaldehyde

Table A1.2.24: Alternative D VOC Emission Factors for Dehydration and Condensate Tank Flashing During Production Operations

VOC Emission Factors Dehydration and Condensate Tank Flashing

Dehydration VOC Emissions
0.3759 lb/hr per MMSCF per day [a]

[a] Generated from GRI-GLYCalc Version 4.0 and South Piney AQ Analysis

Emission factor changed from 0.2164 lb/hr to 0.3759 lb/hr due to adding C9 and C10 components from S. Piney gas analysis

Flashing Emissions	
0.023 lb/hr controlled [a]	0.387 lb/hr uncontrolled [a]

[a] from E&P Tank Version 2.0 as per South Piney AQ Analysis

Table A1.2.25: Alternative D VOC Emissions for Dehydration and Condensate Task Flashing During Production Operations

Estimate for Dehydration VOC Emissions per year

VOC Emission Factor lb/hr	Total Number of Wells	Hours of Operation per year	Total VOC Emissions tpy	(lb/hr/source)						ton/year/source				
				VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
0.3759	2273	8760	3742	854	60	209	17	10	201	264	914	73	45	879

Assume 0.3 MMSCF gas production per well per day, based on input from Questar

Estimate for VOC Controlled Condensate Tank Flashing and Flaring Emissions per year

Total Field Condensate bbl/day	Total Number of Condensate Tanks	VOC Controlled Emission Factor lb/hr	Hours of Operation per year	Total VOC Emissions tpy	(lb/hr/source)						ton/year/source				
					VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
15,911	1,591	0.023	8760	160	37	3	9	1	0	9	11	39	3	2	38

Assume 10 barrels of condensate and produced water per MMCF
HAP emissions represented on summary tables
Assume 70% of condensate tanks operate with a combustion chamber emission control device

Estimate for VOC Uncontrolled Condensate Tank Flashing Emissions per year

Total Field Condensate bbl/day	Total Number of Condensate Tanks	VOC Uncontrolled Emission Factor lb/hr	Hours of Operation per year	Total VOC Emissions tpy	(lb/hr/source)						ton/year/source				
					VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
6,819	682	0.387	8760	1156	264	19	64	5	3	62	82	282	23	14	272

Assume 10 barrels of condensate and produced water per MMCF
HAP emissions represented on summary tables
Assume 30% of condensate tanks operate without an emission control device
Assume one tank per well

<u>Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation</u>
hours per year = 8760

Table A1.2.26: Alternative D Emission Factors for Dehydrator Heaters for Production Operations

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10} [a]	SO_2	CO	VOC
lb/MMscf	100	7.6	0.6	84	5.5
lb/MMBtu [b]	9.80E-02	7.45E-03	5.88E-04	8.24E-02	5.39E-03

[a] From BLM, 2003. Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}.

[b] From BLM, 2003. Assumed a fuel heating value of 1,020 Btu/scf.

Source: EPA, *AP-42* , Volume I, Section 1.4 Natural Gas Combustion (7/98).

Table A1.2.27: Alternative D Emissions Estimates for Dehydrator Heaters for Production Operations

Emission Estimate for Dehydrator Heaters

Operating Hours per Year [a]	Dehydrator Heater Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Wells	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.10	0.21	2273	24	2	0	20	1	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day
Assume Dehydrator Heater Operation at each well site
HAP emissions represented on summary tables

Table 1.2.28: Alternative D Emission Factors for Three-Phase Separator Heaters

Emission Factors for Three-Phase Separator Heaters

Unit	NO_x	PM_{10} [a]	SO_2	CO	VOC
lb/MMscf	100	7.6	0.6	84	5.5
lb/MMBtu [b]	9.80E-02	7.45E-03	5.88E-04	8.24E-02	5.39E-03

Table A1.2.29: Alternative D Emissions Estimates for Three-Phase Separator-Heaters

Emission Estimates for Three Phase Separator Heaters

Operating Hours per Year [a]	Separator Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Wells	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.75	1.61	2273	183	14	1	154	10	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day

Assume Dehydrator Heater Operation at each well site

Table A1.2.30: Alternative D Emissions Estimates for Condensate Tank Heaters

Emission Estimates for Condensate Tank Heaters

Operating Hours per Year [a]	Tank Heater Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Condensate Tanks	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.50	1.07	2273	122	9	1	102	7	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day

Assume a separator and heater for each well

Table A1.2.31: Alternative D Emission Estimates for Produced Water Tank Heaters

Emission Estimates for Produced Water Tank Heaters

Operating Hours per Year [a]	Tank Heater Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Produced Water Tanks	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.50	1.07	2273	122	9	1	102	7	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day

Assume a heater for each tank

Table A1.2.32: Alternative D Fugitive Dust Emission Factors for Production Operations Road Traffic

Emission Factors for Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^a(W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
CE = control efficiency for watering (%)	50	EPA, *Control of Open Fugitive Dust Sources*, Section 5.3.1 Watering of Unpaved Surfaces (1988)

Table A1.2.33: Alternative D Fugitive Dust Emissions Estimates for Production Operations Road Traffic

Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle Type	Av. Vehicle Weight (lb)	Total # of Operating Stations	Total # Inspection Visits per Station per year	Total # of Inspection Visits per year	Total # Miles per Inspection	PM_{10} Em. Factor (lb/VMT) a	PM_{10} Emissions (lb/stn-yr)	PM_{10} Emissions (ton/proj.)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lb/stn-yr)	$PM_{2.5}$ Emissions (ton/proj.)	Emissions (lb/hr/stn) PM_{10}	Emissions (lb/hr/stn) $PM_{2.5}$
Inspection Visits for Compressor Stations	Central Compressor Station	Pickup Truck	7,000	8	52	416	10	0.63	6.3	1.3	0.09	0.9	0.20	0.0050609	0.001053
								Total		1.3			0.2		

[a] BLM, 2003. Table APP_A21, field and sales compressors are visited using a 200 hp pick up truck (4 wheels) once a week

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per inspection = 24

Table A1.2.34: Alternative D Exhaust Emission Factors for Production Operations Road Traffic

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] From BLM, 2003, table 1.1.2.2

[b] Including tire and brake wear emissions.

Source: EPA, *AP-42*, Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II (High Altitude; Model Year 1991-1997; 50,000 mileage) (1985).

Table A1.2.35: Alternative D Exhaust Emissions Estimates for Production Operations Road Traffic

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle Type	Av. Vehicle Weight (lb)	Total # of Operating Stations	Total # Inspection Visits per Station per year	Total # of Inspection Visits per year	Total # Miles per Inspection	Emissions																										
								(lb/station-yr)						(ton/project)											(lb/hr/stn)									
								NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Inspection Visits for Compressor Stations	Central Compressor Station	Pickup Truck	7,000	8	52	416	10	0.02	0.00	0.00	0.00	0.26	0.02	0.005	0.000	0.000	0.001	0.053	0.003	0	0	0	0	0	1.7E-06	1.3E-06	1.99E-06	0.00021	1.3E-05	0	0	0	0	0
												Total		**0.00**	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**															

[a] BLM, 2003. Table APP_A21, field and sales compressors are visited using a 200 hp pick up truck (4 wheels) once a week

Emissions per well = emission factor g/mile*total miles per inspection/453.6 g/lb

Table A1.2.36: Alternative D Fugitive Dust Emission Factors for Well Workover Road Traffic

Emission Factors for Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^a(W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W= mean vehicle weight (tons)	60	Assume workover rig 120,000 lbs
W= mean vehicle weight (tons)	30	Assume haul truck 60,000 lbs
W = mean vehicle weight (tons)	3.5	Assume pickup truck weight of 7,000 lbs
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
CE = control efficiency for watering (%)	50	EPA, *Control of Open Fugitive Dust Sources*,

Table A1.2.37: Alternative D Fugitive Dust Emissions Estimates for Well Workover Road Traffic

Fugitive Dust Emissions Estimation for Road Traffic															
							PM_{10}			$PM_{2.5}$					ton/year/well
							Emission Factor	Emissions		Emission Factor	Emissions		lb/hr/well		
Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi)	# of Round Trips per Well	Miles Traveled per Well	Total # of Wells Drilled	(lb/VMT)	(lb/well)	ton/proj.	(lb/VMT)	(lb/well)	(ton/proj.)	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Well Workover	Workover Rig	120,000	3	2	6	114	2.6	16	1	0.1	1	0.0	0.32689	0.012	#####
	Haul Truck	60,000	3	2	6	114	1.8	11	1	0.4	2	0.1	0.23114	0.044	#####
	Pickup Truck	7,000	3	2	6	114	0.6	4	0	0.2	1	0.1	0.07895	0.022	#####
							Total		2			0.2			

[a] BLM, 2003. Table APP_A21.
[b] BLM, 2003. No dust control measures would be applied.

Table A1.2.38: Alternative D Exhaust Emission Factors for Well Workover On-Site Industrial Engines

Emission Factors for Industrial Engines					
Fuel Type	Emission Factors (lb/hp-hr)				
	NO_x	PM_{10}	SO_x	CO	VOC
Diesel	2.40E-02	5.73E-04	4.05E-04	5.50E-03	7.05E-04

EPA, *AP-42* , Volume I, Section 3.4 Large Stationary Diesel and all Stationary Dual Fuel Engines (10/96).

Table A1.2.39: Alternative D Exhaust Emission Estimates for Well Workover On-Site Industrial Engines

On-Site Exhaust Emissions Estimation for Industrial Engines

Activity	Equipment	Capacity (hp)	Ave. Operating Load Factor (%)	Operating Hours per well	Total # of Wells Drilled	Emissions (lb/well)					Emissions (ton/project)					Emissions lb/hr/source									ton/year/source)							
						NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM_{10}	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	NO_x	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Well Workover	Truck-Mounted Unit	600	0.7	30	114	302	7	5	69	9	17	0.4	0.3	4.0	0.5	0.2	0.2	2.3	0.3	0	0	0	0	0	0.17	2.31	0.2961	0	0	0	0	0

Emissions per well = emission factor lb/hp-hr*engine hp rating*operating hours*engine load factor %

NOx Emissions= $\frac{\text{302 lb/well*114 wells}}{\text{2000lb/ton}}$ = 17 tons

Table 63: Alternative D Exhaust Emission Factors for Well Workover Road Traffic

Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light Duty Gasoline Truck (LDGT2)	1.01	0.10	0.08	0.11	11.64	0.75
Heavy-Duty Diesel Truck (HDDV)	8.13	1.96	1.81	1.63	17.09	4.83

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).

[b] BLM, 2003. Including tire and brake wear emissions.

Source: EPA (1985), AP-42, Volume II, Appendix H-259, Table 7.1.2 Heavy Duty Diesel Powered Vehic
(High Altitude; Model Year 1991-1997; 50,000 mileage).

Table A1.2.41: Alternative D Exhaust Emission Estimates for Well Workover Road Traffic

On-Road Exhaust Emissions Estimation for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (mi)	Round Trip Per Well	Miles Traveled per Well	Total # of Wells Drilled	Emissions (lb/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(ton/project) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC
Well Workover	Workover Rig	HDDV	3	2	6	114	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	Haul Truck	HDDV	3	2	6	114	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	Pickup Truck	LDGT2	3	2	6	114	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
						TOTAL							**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Vehicle Type	(lb/hr/source) PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	(tons/year/source) NO_x	$PM_{2.5}$	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Workover Rig	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0.0	0.0	0.0	0.0	0	0	0	0	0
Haul Truck	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0.0	0.0	0.0	0.0	0	0	0	0	0
Pickup Truck	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0.0	0.0	0.0	0.0	0	0	0	0	0

Workover Rig

Emissions per well = <u>emission factor g/mile*distance in miles</u> / (453.6 g/lb)

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only, Workover Rig) = 24

hours per round trip (driving time only, Haul Truck) = 24

hours per round trip (driving time only, Pickup Truck) = 24

Table A1.2.42: Alternative D Fugitive Dust Emissions for Well and Pipeline Road Traffic

Emission Factors for Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^{a}(W/3)^{d}}{(M/0.2)^{c}}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98)
Control efficiency for watering (%) =	50	EPA, *Control of Open Fugitive Dust Sources* , Section 5.3.1 Watering of Unpaved Surfaces (1988)

Table A1.2.43: Alternative D Fugitive Dust Emission Estimates for Well and Pipeline Road Traffic

Well & Pipeline Fugitive Dust Emissions Estimation for Road Traffic

Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi/day)	# of Wells Visited per Day [a]	# of Visits per Well per Year [b]	Miles Traveled per Well per Year	Total # of Operating Well-Yr	PM_{10} Em. Factor (lb/VMT) [c]	PM_{10} Emissions (lb/well-yr)	PM_{10} Emissions (ton/proj.)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions lb/well-yr	$PM_{2.5}$ Emissions (ton/proj.)
Visits for Inspection and Repair	200-hp Pickup	7,000	75	120	2	1.25	114	0.63	0.8	0	0.09	0.1	0.0

[a] BLM, 2003. Table APP_A21.xls
[b] BLM, 2003. Table APP_A21.xls
[c] BLM, 2003. Table APP_A21.xls

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation
hours per round trip (driving time only,200-hp Pickup) = 24

Table A1.2.44: Alternative D Exhaust Emission Factors for Well and Pipeline Road Traffic

Exhaust Emission Factors for Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] From BLM, 2003, table 1.1.2.2

[b] From BLM, 2003, table 1.1.2.2; including tire and brake wear emissions.

Source: EPA, *AP-42* , Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II (High Altitude; Model Year 1991-1997; 50,000 mileage) (1985).

Table A1.2.45: Alternative D Exhaust Emission Estimates for Well and Pipeline Road Traffic

Well & Pipeline Exhaust Emissions Estimation for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (mi/day)	# of Wells Visited per Day [a]	# of Visits per Well per Year [b]	Miles Traveled per Well per Year	Total # of Operating Well-Yr
Visits for Inspection and Repair	200-hp Pickup	LDGT2	75	120	2	1.25	114

Emissions:

Activity	(lb/well-yr) NO_x	(lb/well-yr) PM_{10}	(lb/well-yr) $PM_{2.5}$	(lb/well-yr) SO_x	(lb/well-yr) CO	(lb/well-yr) VOC	(ton/project) NO_x	(ton/project) PM_{10}	(ton/project) $PM_{2.5}$	(ton/project) SO_x	(ton/project) CO	(ton/project) VOC
Visits for Inspection and Repair	0.00	0.000	0.000	0.000	0.0	0.00	0.00	0.000	0.000	0.000	0.0	0.00

Activity	(lb/hr/source) PM_{10}	(lb/hr/source) $PM_{2.5}$	(lb/hr/source) SO_x	(lb/hr/source) CO	(lb/hr/source) VOC	(lb/hr/source) Benzene	(lb/hr/source) Toluene	(lb/hr/source) Ethyl-benzene	(lb/hr/source) Hexane	(lb/hr/source) Xylene
Visits for Inspection and Repair	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0

Activity	(ton/year/source) NO_x	(ton/year/source) $PM_{2.5}$	(ton/year/source) SO_x	(ton/year/source) VOC	(ton/year/source) Benzene	(ton/year/source) Toluene	(ton/year/source) Ethyl-benzene	(ton/year/source) Hexane	(ton/year/source) Xylene
Visits for Inspection and Repair	0.00	0.00	0.00	0.00	0	0	0	0	0

[a] From BLM, 2003, APP_A21, table 1.2.5.2
[b] Wells visited once per month

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation
hours per round trip (driving time only,200-hp Pickup) = 24

Table A1.2.46: Alternative D Road Maintenance Emissions Estimation Information

Maintenance [a]	Equipment/Vehicle			Road Length Worked On per Day	# of Operating Hours per Day
	Type	Fuel	Capacity (hp)		
Summer	Heavy Equipment [b]	Diesel	135 [c]	6	10
	Commuting Vehicle	Gasoline	225	6 [d]	1 [e]
Winter	Heavy Equipment [b]	Diesel	135 [c]	5	10
	Commuting Vehicle	Gasoline	225	6 [d]	1.5 [e]

[a] BLM, 2003. Road maintenance would be made twice in summer and once in winter every year.
[b] BLM, 2003. Assume a motor grader.
[c] BLM, 2003. Assume 135 hp.
[d] BLM, 2003. Average round trip mileage on unpaved road**.**
[e] BLM, 2003. Assume one round trip per day.

Estimation of Total and Cumulative Length of Roads	
Total Length of Roads Built (mi/pad) [a,b]	0.9
Cumulative Length of Roads Maintained [c] (mi)	14

[a] Reflects combination of drilling and producing roads
[b] = drilling roads 0.5 mile per well and access roads are 0.4 mile per well for a total of 0.9 mile per well pad
[c] = 0.9 miles of road built per pad*1861 well pads = 1,675 miles of roads to maintain

Estimation of Total Operation Days and Hours

Season	# of Operation per Year	Cumulative Length of Roads (mi-yr)	Road Length Worked On (mi/day)	# of Operating Hours per Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	14	6	10	5	48
Winter	1	14	5	10	3	29
				Total	**8**	**77**

Emission Factors for Grader

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

[a] Assumed a mean vehicle speed (S) of 5 mph. (BLM, 2003)
Source: EPA, *AP-42* , Volume I, Section 11.9 Western Surface Coal Mining (10/98).

Table A1.2.47: Alternative D Road Maintenance Fugitive Dust Emission Factors for Grader

Emission Factors for Grader

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

[a] Assumed a mean vehicle speed (S) of 5 mph. (BLM, 2003)
Source: EPA, *AP-42* , Volume I, Section 11.9 Western Surface Coal Mining (10/9

Table A1.2.48: Alternative D Road Maintenance Fugitive Dust Emissions Estimates for Grader

Fugitive Dust Emissions Estimation for Grader

Activity	Equipment	Total # of Operating Hours [a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$		lb/hr/well		ton/year/well
					Em. Factor (lb/VMT)	Emissions (ton/proj.)	Em. Factor (lb/VMT)	Emissions (ton/proj.)	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Road Maintenance	Grader	6,546	5	32,731	0.765	13	0.069	1.1	0.153	0.013864	0.0005

[a] Assumed that a grader would operate for 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities. (BLM, 200

Table A1.2.49: Alternative D Road Maintenance Exhaust Emission Factors for Grader

Emission Factors for Grader

Equipment	Emission Factors (g/hp-hr)				
	NO_x	PM_{10} [a]	SO_2	CO	VOC
Grader	7.14	0.63	0.87	1.54	0.36

[a] Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}. (BLM, 2003)

Source: EPA, *AP-42* , Volume II, Section II-7 Heavy-Duty Construction Equipment (1985).

Table A1.2.50: Alternative D Road Maintenance Exhaust Emissions Estimates for Grader

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (lb/hr)					Emissions (ton/project)					Emissions (ton/year/source)							
				NO_x	PM_{10} [b]	SO_x	CO	VOC	NO_x	PM_{10} [b]	SO_x	CO	VOC	NO_x	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Road Maintenance	Grader	135	6,546	2.13	0.19	0.26	0.46	0.11	7	0.6	0.9	1.5	0.4	0	0	0	0	0	0	0	0

[a] Assumed that a grader would operate for 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities. (BLM, 2003)
[b] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.

Table A1.2.51: Alternative D Fugitive Dust Emission Factors for Commuting Maintenance Vehicles

Emission Factors for Commuting Maintenance Vehicles Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^a (W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	2.6	0.38
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,200
M = surface material moisture content (%)	0.2	BLM, 2003. Default value in EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads
Control efficiency for watering (%) =	50	BLM, 2003. EPA, *Control of Open Fugitive Dust Sources* , Section 5.3.1 Watering of Unpaved Surfaces (1988)

Table A1.2.52: Alternative D Fugitive Dust Emission Estimates for Commuting Maintenance Vehicles

Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT) [a]	Emissions (ton/proj.)	Em. Factor (lb/VMT) [a]	Emissions (ton/proj
Road Maintenance	Pickup Truck	7,000	6	1,091	6,546	0.63	2.1	0.09	0.3

[a] No dust control measures would be applied (BLM, 2003).

Table A1.2.53: Alternative D Exhaust Emission Factors for Commuting Maintenance Vehicles

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).

[b] BLM, 2003. Including tire and brake wear emissions.

Source: EPA (1985), AP-42, Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II

Table A1.2.54: Alternative D Exhaust Emission Estimates for Commuting Maintenance Vehicles

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (mi/day)	Total # of Operating Days	Total Miles Traveled	Emissions (ton/project)					
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC
Road Maintenance	Pickup Truck	LDGT2	6	1,091	6,546	0.01	0.001	0.001	0.001	0.08	0.01

$$\text{Emissions} = \frac{\text{emission factor g/mile*total distance in miles}}{\text{(453.6 g/lb)(2000lb/ton)}}$$

Table A1.2.55: Alternative D Fugitive Emission Factors for Long-Term Production Operations. Compressor Maintenance Vehicles Road Traffic.

Emission Factors for Compressor Maintenance Vehicles Road Traffic: Long-term Production

$$E\ [lb/VMT] = \frac{k(s/12)^a(W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42* , Volume I, Section 13.2.2 Unpaved Roads (9/98)
Control efficiency for watering (%) =	50	EPA, *Control of Open Fugitive Dust Sources* , Section 5.3.1 Watering of Unpaved Surfaces

Table A1.2.56: Alternative D Fugitive Emissions Estimates for Long-Term Production Operations. Compressor Maintenance Vehicles Road Traffic.

Fugitive Dust Emissions Estimation for Compressor Maintenance Vehicles Road Traffic: Long-term Production

Activity	Vehicle Type	Av. Vehicle Weight (lb)	Compressor Station	# of Stations	# of Visits per Year	Total # of Round Trips	Round Trip Distance (mi)	Total Miles Traveled	PM_{10}		PM2.5	
									Em. Factor (lb/VMT) [a]	Emissions (ton/proj.)	Em. Factor (lb/VMT) [d]	Emissions (ton/proj.
Maintenance Visits to Central Compressor Stations	Pickup Truck	7,000	Central Compressor Station	8	3	24	3	72	0.63	0.0	0.09	0.0
								Total		**0.0**		**0.0**

[a] No dust control measures would be applied (BLM, 2003, table APP_A21.xls).

<u>Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation</u>

hours per round trip (driving time only, Pickup) = 24

Table 64: Alternative D Exhaust Emission Factors for Long-Term Production Operations. Compressor Maintenance Vehicles Road Traffic.

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic: Long-term Production

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).

[b] BLM, 2003. Including tire and brake wear emissions.

Source: EPA (1985), AP-42, Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II

Table A1.2.58: Alternative D Exhaust Emissions Estimates for Long-Term Production Operations. Compressor Maintenance Vehicles Road Traffic.

Emissions Estimation for Road Traffic

Activity	Vehicle		Compressor Station	# of Stations	# of Visits per Year	Total # of Round Trips	Round Trip Distance (mi)	Total Miles Traveled	Emissions										
									(ton/project)										
	Type	Class							NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Maintenance Visits to Compressor Stations	Pickup Truck	LDGT2	Central Compressor Station	8	2	16	10	160	0.000	0.0000	0.0000	0.0000	0.002	0.000	0	0	0	0	0
Total									**0.000**	**0.0000**	**0.0000**	**0.0000**	**0.00**	**0.000**					

Emissions per Station = $\frac{\text{emission factor g/mile*total distance in miles}}{\text{(453.6 g/lb)(2000lb/ton)}}$

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only, Pickup) = 24

Table A1.2.59: Alternative D Natural Gas Well Condensate VOC Emissions

Tanks 4.0 Natural Gas Well Condensate VOC Emissions

City: Price, Utah
Type of Tank: Vertical Fixed Roof
Size: 400 bbl
Shell height: 20 ft   Diameter: 12 ft
Ave. Liquid height: 10 ft   Turnovers: 12
Color: White
Assume 9 bbl per MMCF gas production

Natural Gas Well Condensate VOC Emissions

	VOC Losses				
Components	**Working Loss (lbs)[a]**	**Breathing Loss (lbs)[a]**	**Total Emissions per tank (lbs)**	**Total Number of Tanks**	**Total Tank Emissions (tpy)**
Gasoline (RVP8)	**1082.95**	**985**	**2068**	**88**	**91.07**

Meteorological Data used in Emissions Calculations: Grand Junction, Colorado (Avg Atmospheric Pressure = 12.27 psia)
[a] Calculated from Tanks 4.0

Table A1.2.60: Alternative D Natural Gas Well Condensate Truck Loadout VOC and HAP Emissions

Natural Gas Well Condensate Truck Loadout VOC Emissions

Emissions were estimated based on Equation (1) of AP-42, Section 5.2

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

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 = 1.45 (From Table 5.2-1, splash loading into tanker truck)

P = 8.0 psia

M = 68 lbs/lb-mole

T = 512.62, liquid bulk temp is 52.95 (from Tanks 4.0)

L_L = 12.46 (1.45*8*68)/512.62 **19.17297023**

L_L = 19.17 lbs/1,000 gal

Natural Gas Well Condensate Truck Loadout VOC Emissions

Pollutant	Emission Factor (lbs/1,000 gallons)	Annual Condensate Volume bbl [a]	Condensate (1,000 gallons)	Total Emissions tpy	lb/hr/source VOC	lb/hr/source Benzene	lb/hr/source Toluene	lb/hr/source Ethyl-benzene	lb/hr/source Hexane
VOCs	**19.17**	**4,977,870**	**209,071**	**4**	0.81992976	3.4E-06	2E-07	2E-06	6.4E-05

a Assume 50,000CFY conventional gas production, 9 bbl condensate per MMCF gas production

<u>Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation</u>

hours per year that condensate tank has working and breathing losses (total emissions) = 8760

hours per year that condensate truck loadout occurs (used in calculation) = 8760

VOC and HAP emissions from Table B.2.8 of Jonah Technical Support Document; listed for Condensate Storage Tank

Compound	TPY per tank: Controlled 98%	TPY per tank: Uncontrolled
VOC	1	15.9
HAP	0.1	0.8
Benzene	0.0024	0.0367
Toluene	0.0001	0.0021
Ethylbenzene	0.0014	0.022
n-Hexane	0.0443	0.6891
Xylene	0.0018	0.0279

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APPENDIX B

Project Emissions Inventory for Oil Well Production

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Table B1.1.1: Alternatives A/B/C Emission Factors for Three-Phase Separator Heaters

Emission Factors for Three-Phase Separator Heaters

Unit	NO_x	PM_{10} [a]	SO_2	CO	VOC
lb/MMscf	100	7.6	0.6	84	5.5
lb/MMBtu [b]	9.80E-02	7.45E-03	5.88E-04	8.24E-02	5.39E-03

Table B1.1.2: Alternatives A/B/C Emission Estimates for Three-Phase Separator Heaters

Emission Estimates for Three Phase Separator Heaters

Operating Hours per Year [a]	Separator Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Wells	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.75	1.61	606	1	4	0	41	3	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day 0.0013
Assume Dehydrator Heater Operation at each well site

Table B1.1.3: Alternatives A/B/C Fugitive Dust Emission Factors for Well Workover Road Traffic

Emission Factors for Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^a (W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W= mean vehicle weight (tons)	60	Assume workover rig 120,000 lbs
W= mean vehicle weight (tons)	30	Assume haul truck 60,000 lbs
W = mean vehicle weight (tons)	3.5	Assume pickup truck weight of 7,000 lbs
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads
CE = control efficiency for watering (%)	50	EPA, *Control of Open Fugitive Dust Sources*,

Table B1.1.4: Alternatives A/B/C Fugitive Dust Emission Estimates for Well Workover Road Traffic

Fugitive Dust Emissions Estimation for Road Traffic

Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi)	# of Round Trips per Well	Miles Traveled per Well	Total # of Wells Drilled	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lb/well)	PM_{10} Emissions ton/proj.	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lb/well)	$PM_{2.5}$ Emissions (ton/proj.)	lb/hr/well PM_{10}	lb/hr/well $PM_{2.5}$	ton/year/well $PM_{2.5}$
Well Workover	Workover Rig	120,000	3	2	6	0	2.6	16	0	0.1	1	0.0	0.32689	0.012	0.0003
	Haul Truck	60,000	3	2	6	0	1.8	11	0	0.4	2	0.0	0.23114	0.044	0.0011
	Pickup Truck	7,000	3	2	6	0	0.6	4	0	0.2	1	0.0	0.07895	0.022	0.0005
							Total		**0**			**0.0**			

[a] BLM, 2003. Table APP_A21.
[b] BLM, 2003. No dust control measures would be applied.

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only, Workover Rig) = 24
hours per round trip (driving time only, Haul Truck) = 24
hours per round trip (driving time only, Pickup Truck) = 24

Table B1.1.5: Alternatives A/B/C Exhaust Emission Factors for Well Workover On-Site Industrial Engines

Emission Factors for Industrial Engines					
Fuel Type	Emission Factors (lb/hp-hr)				
	NO_x	PM_{10}	SO_x	CO	VOC
Diesel	2.40E-02	5.73E-04	4.05E-04	5.50E-03	7.05E-04

EPA, *AP-42* , Volume I, Section 3.4 Large Stationary Diesel and all Stationary Dual Fuel Engines (10/96).

Table B1.1.6: Alternatives A/B/C Exhaust Emission Estimates for Well Workover On-Site Industrial Engines

On-Site Exhaust Emissions Estimation for Industrial Engines

Activity	Equipment	Capacity (hp)	Ave. Operating Load Factor (%)	Operating Hours per well	Total # of Wells Drilled	Emissions																										
						(lb/well)					(ton/project)					lb/hr/source									ton/year/source)							
						NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM_{10}	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	NO_x	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Well Workover	Truck-Mounted Unit	600	0.7	30	0	302	7	5	69	9	0	0.0	0.0	0.0	0.0	0.2	0.2	2.3	0.3	0	0	0	0	0	0.17	2.31	0.2961	0	0	0	0	0

Emissions per well = emission factor lb/hp-hr*engine hp rating*operating hours*engine load factor %

NOx Emissions= 302 lb/well*0 wells / 2000lb/ton = 0 tons

Table B1.1.7: Alternatives A/B/C Road Maintenance Emissions Estimation Information

Maintenance [a]	Equipment/Vehicle			Road Length Worked On per Day	# of Operating Hours per Day
	Type	Fuel	Capacity (hp)		
Summer	Heavy Equipment [b]	Diesel	135 [c]	6	10
	Commuting Vehicle	Gasoline	225	6 [d]	1 [e]
Winter	Heavy Equipment [b]	Diesel	135 [c]	5	10
	Commuting Vehicle	Gasoline	225	6 [d]	1.5 [e]

[a] BLM, 2003. Road maintenance would be made twice in summer and once in winter every year.
[b] BLM, 2003. Assume a motor grader.
[c] BLM, 2003. Assume 135 hp.
[d] BLM, 2003. Average round trip mileage on unpaved road.
[e] BLM, 2003. Assume one round trip per day.

Estimation of Total and Cumulative Length of Roads	
Total Length of Roads Built (mi/pad) [a,b]	0.9
Cumulative Length of Roads Maintained [c] (mi)	545

[a] Reflects combination of drilling and producing roads
[b] = drilling roads 0.5 mile per well and access roads are 0.4 mile per well for a total of 0.9 mile per well pad
[c] = 0.9 miles of road built per pad*1861 well pads = 1,675 miles of roads to maintain

Table B1.1.8: Alternatives A/B/C Road Maintenance Fugitive Dust Emissions Factors for Grader

Estimation of Total Operation Days and Hours

Season	# of Operation per Year	Cumulative Length of Roads (mi-yr)	Road Length Worked On (mi/day)	# of Operating Hours per Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	545	6	10	182	1,818
Winter	1	545	5	10	109	1,091
				Total	**291**	**2,909**

Emission Factors for Grader

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

[a] Assumed a mean vehicle speed (S) of 5 mph. (BLM, 2003)
Source: EPA, *AP-42* , Volume I, Section 11.9 Western Surface Coal Mining (10/98).

Table B1.1.2: Alternatives A/B/C Road Maintenance Fugitive Dust Emissions Estimates for Grader

Fugitive Dust Emissions Estimation for Grader

Activity	Equipment	Total # of Operating Hours [a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$		lb/hr/well		ton/year/well
					Em. Factor (lb/VMT)	Emissions (ton/proj.)	Em. Factor (lb/VMT)	Emissions (ton/proj.)	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Road Maintenance	Grader	1,745	5	8,726	0.765	3	0.069	0.3	0.153	0.013864	0.0005

[a] Assumed that a grader would operate for 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities. (BLM, 200

Table B1.1.3: Alternatives A/B/C Road Maintenance Exhaust Emission Factors for Grader

Emission Factors for Grader

Equipment		Emission Factors (g/hp-hr)			
	NO_x	PM_{10} [a]	SO_2	CO	VOC
Grader	7.14	0.63	0.87	1.54	0.36

[a] Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}. (BLM, 2003)

Source: EPA, *AP-42* , Volume II, Section II-7 Heavy-Duty Construction Equipment (1985).

Table B1.1.4: Alternatives A/B/C Road Maintenance Exhaust Emission Estimates for Grader

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (lb/hr)					Emissions (ton/project)					Emissions (ton/year/source)							
				NO_x	PM_{10} [b]	SO_x	CO	VOC	NO_x	PM_{10} [b]	SO_x	CO	VOC	NO_x	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Road Maintenance	Grader	135	1,745	2.13	0.19	0.26	0.46	0.11	2	0.2	0.2	0.4	0.1	0	0	0	0	0	0	0	0

[a] Assumed that a grader would operate for 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities. (BLM, 2003)

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

Table B1.1.5: Alternatives A/B/C Fugitive Dust Emission Factors for Commuting Maintenance Vehicles

Emission Factors for Commuting Maintenance Vehicles Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^a (W/3)^d}{(M/0.2)^c}$$

Constant	**PM_{10}**	**$PM_{2.5}$**
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	BLM, 2003. Default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
Control efficiency for watering (%) =	50	BLM, 2003. EPA, *Control of Open Fugitive Dust Sources*, Section 5.3.1 Watering of Unpaved Surfaces (1988)

Table B1.1.6: Alternatives A/B/C Fugitive Dust Emission Estimates for Commuting Maintenance Vehicles

Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi/day)	Total # of Operating Days	Total Miles Traveled	PM_{10} Em. Factor (lb/VMT) [a]	PM_{10} Emissions (ton/proj.)	$PM_{2.5}$ Em. Factor (lb/VMT) [a]	$PM_{2.5}$ Emissions (ton/proj	lb/hr/well PM_{10}	lb/hr/well $PM_{2.5}$	ton/year/ well $PM_{2.5}$
Road Maintenance	Pickup Truck	7,000	6	291	1,745	0.63	0.6	0.09	0.1	0.126321	0.018948	0.0000

[a] No dust control measures would be applied (BLM, 2003).

Table B1.1.7: Alternatives A/B/C Exhaust Emission Factors for Commuting Maintenance Vehicles

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).

[b] BLM, 2003. Including tire and brake wear emissions.

Source: EPA (1985), AP-42, Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II

Table B1.1.8: Alternatives A/B/C Exhaust Emission Estimates for Commuting Maintenance Vehicles

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (mi/day)	Total # of Operating Days	Total Miles Traveled	Emissions (ton/project)					
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC
Road Maintenance	Pickup Truck	LDGT2	6	291	1,745	0.00	0.000	0.000	0.000	0.02	0.00

Emissions = $\dfrac{\text{emission factor g/mile*total distance in miles}}{\text{(453.6 g/lb)(2000lb/ton)}}$

Table B1.1.9: Alternatives A/B/C Fugitive Emissions Factors for Long-Term Production Operations. Oil Tanker Road Traffic.

Emission Factors for Compressor Maintenance Vehicles Road Traffic: Long-term Production

$$E\ [lb/VMT] = \frac{k(s/12)^a (W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
Control efficiency for watering (%) =	50	EPA, *Control of Open Fugitive Dust Sources*, Section 5.3.1 Watering of Unpaved Surfaces

Table B1.1.10: Alternatives A/B/C Fugitive Emissions Estimates for Long-Term Production Operations. Oil Tanker Road Traffic.

Fugitive Dust Emissions Estimation for Oil Tanker Road Traffic: Long-term Production

Activity	Vehicle Type	Av. Vehicle Weight (lb)		# of Stations	# of Visits per Year	Total # of Round Trips	Round Trip Distance (mi)	Total Miles Traveled	PM_{10}		PM2.5	
									Em. Factor (lb/VMT) [a]	Emissions (ton/proj.)	Em. Factor (lb/VMT) [d]	Emissions (ton/proj.
Travel to Transport Oil	Oil Tanker	75,000		606	4	2,424	10	24,240	2.07	25.1	0.31	3.8
								Total		**25.1**		**3.8**

[a] No dust control measures would be applied (BLM, 2003, table APP_A21.xls).

<u>Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation</u>

hours per round trip (driving time only) = 24

Table B1.1.11: Alternatives A/B/C Exhaust Emissions Factors for Long-Term Production Operations. Oil Tanker Road Traffic.

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic: Long-term Production

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Heavy Duty Truck	8.13	1.96	1.81	1.63	17.09	4.83

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).

[b] BLM, 2003. Including tire and brake wear emissions.

Source: EPA (1985), AP-42, Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II

Table B1.1.12: Alternatives A/B/C Exhaust Emissions Estimates for Long-Term Production Operations. Oil Tanker Road Traffic.

Emissions Estimation for Road Traffic

Activity	Vehicle			# of Stations	# of Visits per Year	Total # of Round Trips	Round Trip Distance (mi)	Total Miles Traveled	Emissions (ton/project)										
	Type	Class							NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Maintenance Visits	Oil Tanker	HDDV		606	4	2,424	10	24,240	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
							Total		0.000	0.0001	0.0001	0.0001	0.0008	0.0002					

Emissions per Station = emission factor g/mile*total distance in miles / (453.6 g/lb)(2000lb/ton)

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only) = 24

Table B1.2.1: Alternative D Emission Factors for Three-Phase Separator Heaters

Emission Factors for Three-Phase Separator Heaters

Unit	NO_x	PM_{10} [a]	SO_2	CO	VOC
lb/MMscf	100	7.6	0.6	84	5.5
lb/MMBtu [b]	9.80E-02	7.45E-03	5.88E-04	8.24E-02	5.39E-03

Table B1.2.2: Alternative D Emission Estimates for Three-Phase Separator Heaters

Emission Estimates for Three Phase Separator Heaters

Operating Hours per Year [a]	Separator Size MMBtu/hr	Fuel Usage MMCF/yr	Number of Wells	Total Emissions (ton/year)									
				NOx	PM_{10}	SO_2	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
2,190	0.75	1.61	455	1	3	0	31	2	0	0	0	0	0

[a] Assumed operating 15 minutes per hour per day

Assume Dehydrator Heater Operation at each well site

Table B1.2.3: Alternative D Fugitive Dust Emission Factors for Well Workover Road Traffic

Emission Factors for Road Traffic

$$E\ [lb/VMT] = \frac{k(s/12)^a(W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W= mean vehicle weight (tons)	60	Assume workover rig 120,000 lbs
W= mean vehicle weight (tons)	30	Assume haul truck 60,000 lbs
W = mean vehicle weight (tons)	3.5	Assume pickup truck weight of 7,000 lbs
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads
CE = control efficiency for watering (%)	50	EPA, *Control of Open Fugitive Dust Sources*,

Table B1.2.4: Alternative D Fugitive Dust Emission Estimates for Well Workover Road Traffic

Fugitive Dust Emissions Estimation for Road Traffic															
							PM_{10}			$PM_{2.5}$					ton/year/ well
							Emission Factor	Emissions		Emission Factor	Emissions		lb/hr/well		
Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi)	# of Round Trips per Well	Miles Traveled per Well	Total # of Wells Drilled	(lb/VMT)	(lb/well)	ton/proj.	(lb/VMT)	(lb/well)	(ton/proj.)	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Well Workover	Workover Rig	120,000	3	2	6	0	2.6	16	0	0.1	1	0.0	0.32689	0.012	0.0003
	Haul Truck	60,000	3	2	6	0	1.8	11	0	0.4	2	0.0	0.23114	0.044	0.0011
	Pickup Truck	7,000	3	2	6	0	0.6	4	0	0.2	1	0.0	0.07895	0.022	0.0005
							Total		**0**			**0.0**			

[a] BLM, 2003. Table APP_A21.
[b] BLM, 2003. No dust control measures would be applied.

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only, Workover Rig) = 24
hours per round trip (driving time only, Haul Truck) = 24
hours per round trip (driving time only, Pickup Truck) = 24

Table B1.2.5: Alternative D Exhaust Emission Factors for Well Workover On-Site Industrial Engines

Emission Factors for Industrial Engines					
Fuel Type	Emission Factors (lb/hp-hr)				
	NO_x	PM_{10}	SO_x	CO	VOC
Diesel	2.40E-02	5.73E-04	4.05E-04	5.50E-03	7.05E-04

EPA, *AP-42* , Volume I, Section 3.4 Large Stationary Diesel and all Stationary Dual Fuel Engines (10/96).

Table B1.2.6: Alternative D Exhaust Emission Estimates for Well Workover On-Site Industrial Engines

On-Site Exhaust Emissions Estimation for Industrial Engines

						Emissions																										
						(lb/well)					(ton/project)					lb/hr/source									ton/year/source)							
Activity	Equipment	Capacity (hp)	Ave. Operating Load Factor (%)	Operating Hours per well	Total # of Wells Drilled	NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM_{10}	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene	NO_x	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Well Workover	Truck-Mounted Unit	600	0.7	30	0	302	7	5	69	9	0	0.0	0.0	0.0	0.0	0.2	0.2	2.3	0.3	0	0	0	0	0	0.17	2.31	0.2961	0	0	0	0	0

Emissions per well
= emission factor lb/hp-hr*engine hp rating*operating hours*engine load factor %

NOx Emissions= $\frac{\text{302 lb/well*0 wells}}{\text{2000lb/ton}}$ = 0 tons

Table B1.2.7: Alternative D Road Maintenance Emissions Estimation Information

Maintenance [a]	Equipment/Vehicle			Road Length Worked On per Day	# of Operating Hours per Day
	Type	Fuel	Capacity (hp)		
Summer	Heavy Equipment [b]	Diesel	135 [c]	6	10
	Commuting Vehicle	Gasoline	225	6 [d]	1 [e]
Winter	Heavy Equipment [b]	Diesel	135 [c]	5	10
	Commuting Vehicle	Gasoline	225	6 [d]	1.5 [e]

[a] BLM, 2003. Road maintenance would be made twice in summer and once in winter every year.
[b] BLM, 2003. Assume a motor grader.
[c] BLM, 2003. Assume 135 hp.
[d] BLM, 2003. Average round trip mileage on unpaved road.
[e] BLM, 2003. Assume one round trip per day.

Estimation of Total and Cumulative Length of Roads	
Total Length of Roads Built (mi/pad) [a,b]	0.9
Cumulative Length of Roads Maintained [c] (mi)	545

[a] Reflects combination of drilling and producing roads
[b] = drilling roads 0.5 mile per well and access roads are 0.4 mile per well for a total of 0.9 mile per well pad
[c] = 0.9 miles of road built per pad*1861 well pads = 1,675 miles of roads to maintain

Table B1.2.8: Alternative D Road Maintenance Fugitive Dust Emissions Factors for Grader

Estimation of Total Operation Days and Hours

Season	# of Operation per Year	Cumulative Length of Roads (mi-yr)	Road Length Worked On (mi/day)	# of Operating Hours per Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	545	6	10	182	1,818
Winter	1	545	5	10	109	1,091
				Total	**291**	**2,909**

Emission Factors for Grader

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

[a] Assumed a mean vehicle speed (S) of 5 mph. (BLM, 2003)
Source: EPA, *AP-42* , Volume I, Section 11.9 Western Surface Coal Mining (10/98).

Table B1.2.9: Alternative D Road Maintenance Fugitive Dust Emissions Estimates for Grader

Fugitive Dust Emissions Estimation for Grader

Activity	Equipment	Total # of Operating Hours [a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$		lb/hr/well		ton/year/well
					Em. Factor (lb/VMT)	Emissions (ton/proj.)	Em. Factor (lb/VMT)	Emissions (ton/proj.)	PM_{10}	$PM_{2.5}$	$PM_{2.5}$
Road Maintenance	Grader	1,745	5	8,726	0.765	3	0.069	0.3	0.153	0.013864	0.0005

[a] Assumed that a grader would operate for 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities. (BLM, 200

Table B1.2.13: Alternative D Road Maintenance Exhaust Emission Factors for Grader

Emission Factors for Grader

Equipment	Emission Factors (g/hp-hr)				
	NO_x	PM_{10} [a]	SO_2	CO	VOC
Grader	7.14	0.63	0.87	1.54	0.36

[a] Emission factor for $PM_{2.5}$ was assumed to be the same as that for PM_{10}. (BLM, 2003)

Source: EPA, *AP-42* , Volume II, Section II-7 Heavy-Duty Construction Equipment (1985).

Table B1.2.11: Alternative D Road Maintenance Exhaust Emission Estimates for Grader

Exhaust Emissions Estimation for Grader

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours [a]	Emissions (lb/hr)					Emissions (ton/project)					Emissions (ton/year/source)							
				NO_x	PM_{10} [b]	SO_x	CO	VOC	NO_x	PM_{10} [b]	SO_x	CO	VOC	NO_x	SO_x	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Road Maintenance	Grader	135	1,745	2.13	0.19	0.26	0.46	0.11	2	0.2	0.2	0.4	0.1	0	0	0	0	0	0	0	0

[a] Assumed that a grader would operate for 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities. (BLM, 2003)

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

Table B1.2.12: Alternative D Fugitive Dust Emission Factors for Commuting Maintenance Vehicles

Emission Factors for Commuting Maintenance Vehicles Road Traffic

$$E\ [\text{lb/VMT}] = \frac{k(s/12)^{a}(W/3)^{d}}{(M/0.2)^{c}}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	BLM, 2003. Default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
Control efficiency for watering (%) =	50	BLM, 2003. EPA, *Control of Open Fugitive Dust Sources*, Section 5.3.1 Watering of Unpaved Surfaces (1988)

Table B1.2.13: Alternative D Fugitive Dust Emission Estimates for Commuting Maintenance Vehicles

Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle Type	Av. Vehicle Weight (lb)	Round Trip Distance (mi/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT) [a]	Emissions (ton/proj.)	Em. Factor (lb/VMT) [a]	Emissions (ton/proj
Road Maintenance	Pickup Truck	7,000	6	291	1,745	0.63	0.6	0.09	0.1

[a] No dust control measures would be applied (BLM, 2003).

Table B1.2.14: Alternative D Exhaust Emission Factors for Commuting Maintenance Vehicles

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Light-Duty Gasoline Truck	1.01	0.10	0.08	0.11	11.64	0.75

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).

[b] BLM, 2003. Including tire and brake wear emissions.

Source: EPA (1985), AP-42, Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II

Table B1.2.15: Alternative D Exhaust Emission Estimates for Commuting Maintenance Vehicles

Exhaust Emissions Estimation for Commuting Maintenance Vehicles Road Traffic

Activity	Vehicle		Round Trip Distance (mi/day)	Total # of Operating Days	Total Miles Traveled	Emissions (ton/project)					
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC
Road Maintenance	Pickup Truck	LDGT2	6	291	1,745	0.00	0.000	0.000	0.000	0.02	0.00

$$\text{Emissions} = \frac{\text{emission factor g/mile*total distance in miles}}{(453.6\ \text{g/lb})(2000\text{lb/ton})}$$

Table B1.2.16: Alternative D Fugitive Emissions Factors for Long-Term Production Operations. Oil Tanker Road Traffic.

Emission Factors for Compressor Maintenance Vehicles Road Traffic: Long-term Production

$$E\ [lb/VMT] = \frac{k(s/12)^a (W/3)^d}{(M/0.2)^c}$$

Constant	PM_{10}	$PM_{2.5}$
k	1.8	0.27
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA (1995), AP-42, Section 13.2.2 Unpaved Roads (9/98).

Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
s = surface material silt content (%)	5.1	BLM, 2003. (EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98))
W = mean vehicle weight (tons)	3.5	Assume a light-duty truck of 7,000 lb (BLM,2003)
M = surface material moisture content (%)	0.2	Default value in EPA, *AP-42*, Volume I, Section 13.2.2 Unpaved Roads (9/98)
Control efficiency for watering (%) =	50	EPA, *Control of Open Fugitive Dust Sources*, Section 5.3.1 Watering of Unpaved Surfaces

Table B1.2.17: Alternative D Fugitive Emissions Estimates for Long-Term Production Operations. Oil Tanker Road Traffic.

Fugitive Dust Emissions Estimation for Oil Tanker Road Traffic: Long-term Production

Activity	Vehicle Type	Av. Vehicle Weight (lb)		# of Stations	# of Visits per Year	Total # of Round Trips	Round Trip Distance (mi)	Total Miles Traveled	PM_{10}		PM2.5	
									Em. Factor (lb/VMT) [a]	Emissions (ton/proj.)	Em. Factor (lb/VMT) [d]	Emissions (ton/proj.
Travel to Transport Oil	Oil Tanker	75,000		455	4	1,820	10	18,200	2.07	18.8	0.31	2.8
								Total		**18.8**		**2.8**

[a] No dust control measures would be applied (BLM, 2003, table APP_A21.xls).

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only, Pickup) = 24

Table B1.2.18: Alternative D Exhaust Emissions Factors for Long-Term Production Operations. Oil Tanker Road Traffic.

Exhaust Emission Factors for Commuting Maintenance Vehicles Road Traffic: Long-term Production

Vehicle Class	Emission Factors (g/mi)					
	NO_x	PM_{10} [a,b]	$PM_{2.5}$ [a,b]	SO_x [a]	CO	VOC
Heavy Duty Truck	8.13	1.96	1.81	1.63	17.09	4.83

[a] BLM, 2003. Estimated using the EPA PART5 model (1995).

[b] BLM, 2003. Including tire and brake wear emissions.

Source: EPA (1985), AP-42, Volume II, Appendix H-116, Table 7.1.2 Light Duty Gasoline Powered Trucks II

Table B1.2.18: Alternative D Exhaust Emissions Estimates for Long-Term Production Operations. Oil Tanker Road Traffic.

Emissions Estimation for Road Traffic

Activity	Vehicle			# of Stations	# of Visits per Year	Total # of Round Trips	Round Trip Distance (mi)	Total Miles Traveled	Emissions (ton/project)										
	Type	Class							NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Benzene	Toluene	Ethyl-benzene	Hexane	Xylene
Maintenance Visits to Compressor Stations	Oil Tanker	HDDV		455	4	1,820	10	18,200	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
							Total		**0.000**	**0.0001**	**0.0001**	**0.0001**	**0.0008**	**0.0002**					

Emissions per Station = $\frac{\text{emission factor g/mile*total distance in miles}}{\text{(453.6 g/lb)(2000lb/ton)}}$

Assumptions for converting emissions to lbs/hr/source; used in AERMOD calculation

hours per round trip (driving time only) = 24