OIL AND GAS MOBILE SOURCE EMISSIONS PILOT STUDY
Background Research Report

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INTRODUCTION

The Western Regional Air Partnership (WRAP), state air quality agencies in the Rocky Mountain States, and numerous federal agencies have been sponsoring the development of emissions inventories for oil and gas exploration and production activities in the Rocky Mountain Region. These inventories have been used for purposes of regional haze modeling and studies of ozone formation in attainment and non-attainment areas, as well as for state implementation plans (SIPs) and other policy initiatives. Most recently, WRAP and the Independent Petroleum Association of Mountain States (IPAMS) have jointly co-sponsored a project to develop detailed emissions inventories for all major oil and gas exploration and production activities in the major geologic basins of the Rocky Mountain region (WRAP, 2008). The "Phase III" project represents a substantial improvement in detail and scope over past oil and gas inventories developed by WRAP (Phases I and II; Pollack, et al., 2005; Bar-Ilan, et al., 2007) and includes most major equipment and production processes that lead to emissions of nitrogen oxides (NOx), volatile organic compounds (VOC), sulfur oxides (SOx) and particulate matter (PM). Some of the emissions source categories covered in the Phase III inventories are classified as off-road mobile sources, including drilling rigs and workover rigs which can be significant emissions sources in some basins. However, the majority of source categories considered in the past WRAP regional inventories for oil and gas are either area sources, such as wellhead compressor engines or fugitive emissions, or point sources such as compressor stations or gas processing plants. The WRAP Oil and Gas Workgroup, consisting of representatives of state and federal air quality agencies, industry members, environmental groups, and tribal representatives, has identified the need to better understand and quantify the emissions from on-road and off-road mobile sources operating in the exploration and production sector in oil and gas fields. This emissions category has not been part of the scope of the previous WRAP inventories and is believed to be underestimated in current state-level mobile source emissions inventories.

The WRAP Oil and Gas Workgroup proposed the concept of studying oil and gas mobile source emissions in the form of a pilot study, and the Colorado Department of Public Health and Environment (CDPHE) suggested using the Piceance Basin in Northwestern Colorado as the geographic extent of the pilot study. The U.S. Environmental Protection Agency (EPA) is sponsoring the project and working with WRAP and the Technical Steering Committee for the pilot study in developing the project. The Technical Steering Committee includes members of WRAP, EPA, CDPHE, the Utah Division of Air Quality (UTDAQ), the Wyoming Department of Environmental Quality (WYDEQ), the New Mexico Environment Department (NMED) and county environmental staff from Garfield and Rio Blanco Counties in Northwestern Colorado. As an initial task in the development of the project, the Technical Steering Committee requested that ENVIRON conduct background literature research to determine the extent to which mobile source activity and emissions have been addressed in previous studies, environmental documents or policy guidance documents throughout the Rocky Mountain region. This report documents the results of ENVIRON's literature research.

OBJECTIVES

The literature research focused on three primary objectives:

(1) Reviewing literature associated with oil and gas development for any information on activity or emissions from oil and gas on-road and off-road mobile sources;
(2) Analysis of the literature to identify the range of mobile source activity and emissions estimates developed in the studies reviewed; and
(3) Documentation of the findings from the literature reviewed, including the types of source categories considered, the range of activity estimates for these sources, the types and

sources of emissions factor data used in the study, and the range of emissions estimates in the study.

The specific studies considered, and the findings of the literature review are summarized below.

LITERATURE REVIEW

This section summarizes and discusses the findings of the literature review of on-road and off-road activity data, emission factors and emissions associated with oil and gas development. ENVIRON examined a range of studies that include some data specifically on oil and gas exploration and production related mobile sources. These included: studies specific to individual projects, typically in the form of Environmental Impact Statements (EIS); regional studies by the federal Bureau of Land Management (BLM) which covered either the geographic domain of local field offices or larger regional studies in the form of Resource Management Plans (RMP); and studies specific to oil and gas mobile sources.

A number of criteria were used to evaluate studies for inclusion in the literature review. These included:

- Mobile source estimates – studies that did not explicitly include mobile source activity or emissions estimates were not included in the literature review.
- Geographic proximity – studies that focused on the Piceance Basin, other Colorado oil and gas development areas, or nearby oil and gas development areas with similar production types were considered most relevant to the study.
- Detailed mobile source assumptions and data – only studies that contained some level of detail on the mobile source emissions, the activity assumptions and emissions factors underlying these emissions, the geographic scope of the calculations and other details were included in the literature review. Studies lacking this information were considered insufficiently detailed for inclusion in the literature review.

ENVIRON identified 4 studies for inclusion in the literature review: (1) a study by the Utah Department of Transportation (UDOT) on oil and gas related vehicles traveling on roadways in the Uinta Basin (UDOT, 2008); (2) the Final EIS for the Jonah Infill Drilling Project in the Jonah-Pinedale oil and gas development area in Sublette County, Wyoming (BLM, 2006); (3) the Final EIS for the North San Juan Basin Coal Bed Methane (CBM) project (USFS, 2006); and (4) the RMP for the Little Snake Field Office of the BLM in Northwest Colorado (BLM, 2008). The studies were reviewed with consideration given to the following key features of the study:

- Geographic scope
- Calendar year
- Source categories covered
- Methodology for developing activity data
- Emissions factor sources
- Results
- Uncertainty/error analysis

The results of the analyses of these four documents are presented below.

UDOT – Highway Freight Traffic Associated with the Development of Oil and Gas Wells

In 2006 the UDOT initiated a study to examine on-road vehicle traffic resulting from increased oil and gas activity in the Uinta Basin. UDOT was particularly interested in the increase in truck traffic along the area's primary highway, U.S. Highway 40. The UDOT study focused on developing estimates of on-road truck traffic associated with each element in the development and operation of an oil well. At the time of study, more than 10,000 wells were under construction or planned, in addition to the 5,700 wells that were already active in the basin.

The on-road truck traffic volume estimated from each phase of activity involved in oil and gas well development and operation was based on information provided by the State of Utah Division of Oil, Gas, and Mining (DOGM), the Federal Bureau of Land Management (BLM), various energy development industries and Basin Western Transportation. The UDOT followed up on this data with traffic counts from two permanent count stations located on U.S. Highway 191 and U.S. Highway 40. The detailed results of the study are provided below.

Geographic Scope

Although not specified clearly, it is understood that the UDOT study considered the entire boundaries of the Uinta Basin for purposes of gathering data from various agencies and industry representatives to characterize typical oil and gas mobile source activity. The specific monitors considered in the study are located on U.S. Highway 191 north of Vernal, Utah in Uintah County, and on U.S. Highway 40 at Roosevelt, Utah in Duchesne County. The Uinta Basin geographic boundaries as defined in the WRAP Phase III project are shown below in Figure 1 (Friesen, et al., 2009). Overlaid on this image are the calendar year 2006 locations of active oil and gas wells, by well type including gas wells, oil wells and CBM wells. The boundaries of the tribal airshed in the Uinta Basin are also displayed in the figure, and it should be noted that there is some uncertainty about the boundaries of the airshed over which EPA is administering air quality regulatory authority, and the region over which the UTDAQ is administering air quality regulatory authority. The Uinta Basin primarily consists of Duchesne, Uintah, Carbon, Emery and Grand Counties. Other counties in the basin do not have significant oil and gas activities.

Calendar Year

The study was released in 2006, but references calendar year 2005 traffic count data from the UDOT's permanent traffic count stations. The data gathered by UDOT from various agencies and industry representatives on the per unit on-road activity are not referenced to a specific calendar year. ENVIRON assumes that this data is applicable to 2005 or 2006.

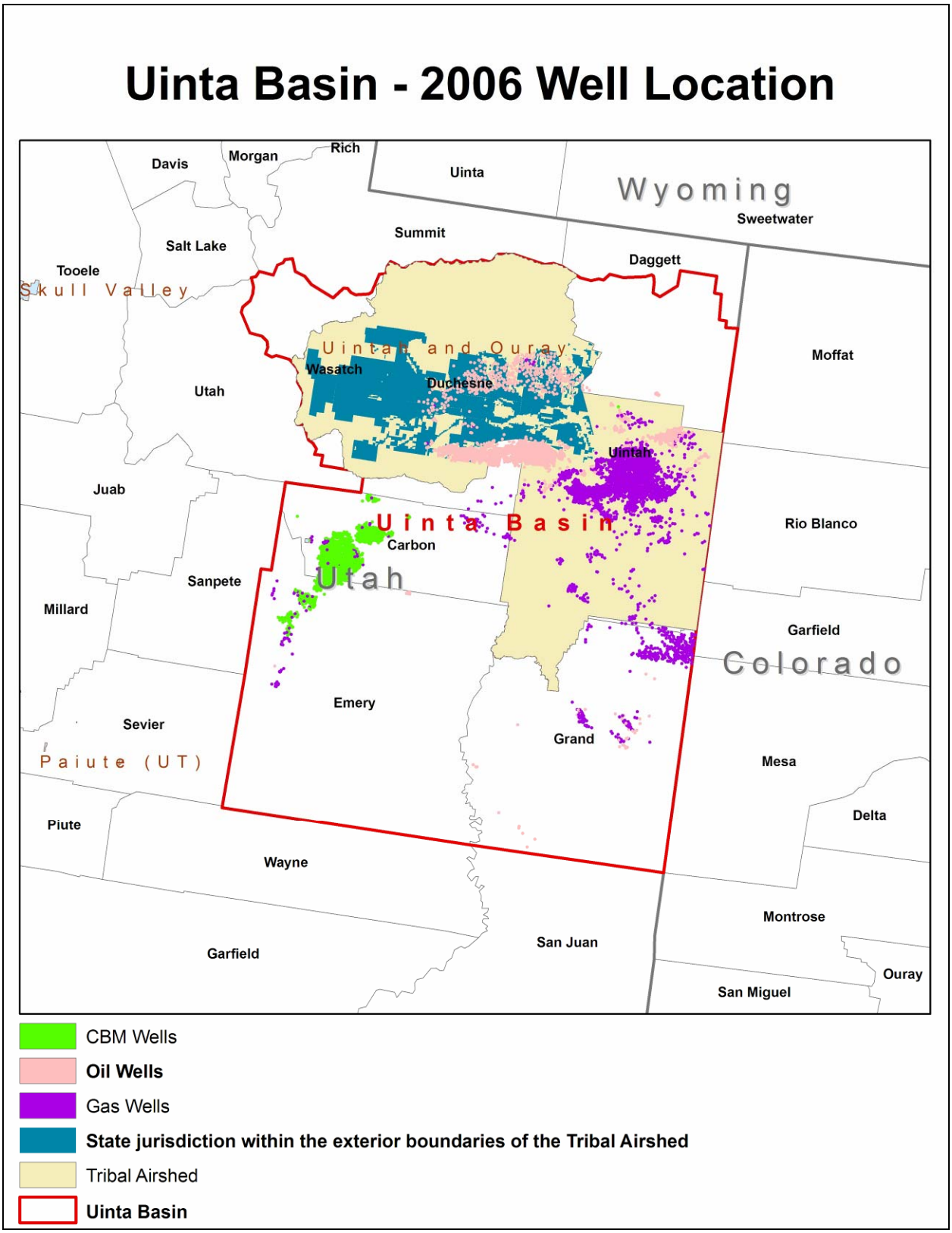

Figure 1. Uinta Basin boundaries overlaid and 2006 oil and gas well locations (source: Friesen, et al., 2009).

Source Categories

The UDOT study focused specifically on on-road truck traffic. Although the study did not specify whether the focus of the traffic estimates were heavy-duty or light-duty trucks, the types of service to which the study refers typically call for heavy-duty trucks. This includes trucking of heavy construction equipment, movement of drill rigs, trucking of supplies including drill strings, water, fracing sand, and tanker trucks to transfer produced oil from oil wells. It is not expected that these types of activities are conducted by light-duty trucks, and no trips associated with worker commutes to a well site are described in the study. The study does not consider traffic associated with large point sources, such as compressor stations or gas processing plants. The specific list of activities for which heavy-duty truck trips are estimated are shown below:

- Ground Surveys
- BLM / Division of Oil and Gas Permitting
- Well Site Development
    - Uinta Basin's northern oil and gas fields (softer soil)
    - Uinta Basin's southern oil and gas fields (ground rocky and harder)
    - Bringing drill rig to well site
- Well Drilling
    - Fresh water for drilling ponds
    - Additional fresh water
    - Waste water / rock disposal
    - Drilling mud (drilling fluid)
    - Well casing
    - Cement powder
- General Rig Maintenance
- Removal of Drilling Rig
- Completion Rig Preparation
- Completion Rig
    - Rig set-up
    - Well tubing
    - Perforate casing and cement outer lining
    - Frac sand
- Remove Completion Rig
- Close Reserve Pits
- Build Facility
- Well Operation
    - Crude oil transport
    - Water removal
    - General well maintenance
    - Pressure maintenance / secondary recovery / disposal wells

It should be noted that based on this list of the scope of the study, it appears that the study focused only on oil wells, and not on gas or CBM wells. However, this was not specified in the study.

Methodology

This study relied on data requested from various federal and state agencies, oil and gas production companies and trucking companies. This data was gathered and is reported as a range of truck trip estimates per well for a number of different activities and processes associated with development of the well. While UDOT also presented data from two permanent traffic count stations in the Uinta Basin, these data were not directly used in the study.

Emissions Factor Sources

The UDOT study did not include estimates of emissions from vehicles, and therefore no emissions factors were used or referenced. The study focused specifically on estimations of truck trips, for purposes of assessing potential impacts to roadways and assessing whether roadway improvements were needed in the Uinta Basin region.

Results

Table 1 below shows the results of the truck trip estimates for different activity types considered in the study. These estimates are the result of information gathering by UDOT from the agencies described above, from outreach to oil and gas industry representatives operating in the Uinta Basin and from outreach to trucking companies.

Table 1. Summary of number of truckloads by activity required for the development of each new well and subsequent operation of the well in the Uinta Basin.

Activity	Traffic Volume (total truckloads)
Survey ground	Limited
BLM/DOG permits	None
Well Site Development	
Uinta Basin's northern oil and gas fields (softer soil)	45
Uinta Basin's southern oil and gas fields (ground rocky and harder)	10 to15
Moving drill rig to well site	30
Drill Well	
Fresh water for drilling ponds	25
Additional fresh water truck loads*	100 to 1000
Waste water/rock disposal	50 to 100
Drill mud (drilling fluid)*	10 to 20
Well casing	10
Cement powder	2 to 4
Drill Well Total	**172 to 1,140**
General rig maintenance	10
Removal of drill rig from well site	30
Completion rig preparation	1 to 2
Completion Rig	
Rig set-up	3 to 4
Well tubing	1 to 2
Perforate casing and cement outer lining	2
Frac sand	
Frac sand mix	5 to 6
Frac tanks	20
Water	100
Completion Rig Totals	**130 to 135**

Activity	Traffic Volume (total truckloads)
Remove completion rig	20 to 25
Close reserve pits	3 to 5
Build facility	10 to 12
Large Truck Movement Totals	**365 – 1,370**
Well Operation	
Crude oil transport**	1 truck per month to 5 trucks per day
Water removal**	1 truck per week to 3 to 5 truckloads per day
General Well Maintenance	
Well corrosion (acid brought to well site every 3 to 5 years)	1 to 2
For entire completion rig returned to well site	25 to 40
Pressure maintenance / secondary recovery / disposal wells	None

*vary by depth of the well
**vary by production of the well

It was concluded that the new oil and gas well development is a transportation intensive operation. The study concluded that to establish a new well, a range of 375-1,375 truckloads are required per well depending upon the depth of the well and its location. The average number of truck loads required for each phase of well development is shown in Table 2. The truck traffic levels associated with existing well operations in the basin were also summarized and are presented in Table 3. Due to increase in oil and gas development and thereby truck traffic, the need for improvement of highway infrastructure was identified and prioritized in the order of greatest impact and importance.

Table 2. Average number of truck loads for each phase of well development in the Uinta Basin.

	Trucks	Days	Trucks Per Day Per Well
Setup	60	3	20
Drilling	800	14	57
Removal	190	3	63

Table 3. Truck traffic in the Uinta Basin associated with existing well operations in 2005/2006.

	Totals
Operating wells	5,700
Truck trips per well per day	0.25
Truck trips per day for all operating wells	1,425
Total energy extraction truck trips per day in Unita Basin	7,585

The study also summarized the findings of the two permanent traffic count stations in Vernal and Roosevelt. Results are presented below in Table 4.

Table 4. Increase in roadway traffic in the Uinta Basin at two traffic count stations.

Station	Truck Traffic Counts (Trucks/day)		
	2003	2005	% Increase (2003 to 2005)
#424 (US 191 north of Vernal)	1,700	4,000	58%
#425 (US 40 at Roosevelt)	7,300	11,500	37%

Uncertainty/Error Analysis

This study did not conduct an explicit uncertainty or error analysis. Some measure of uncertainty in the analysis can be determined from the range of total truck trips per well estimated in the study, which varied from 375-1,375.

Jonah Infill Drilling Project Final Environmental Impact Statement

The Jonah Infill Drilling Project Final EIS (FEIS) contained a detailed air quality analysis of the alternatives considered in the FEIS. The preferred alternative in the FEIS – the Proposed Action – is to expand infill drilling in 16,200 acres of the Jonah area in Sublette County Wyoming with up to 3,100 new wells drilled in a period of 12 years. The FEIS was prepared to analyze the impacts associated with this level of development. The Proposed Action includes an analysis of the roads, pipelines, and other ancillary facilities needed to support the new wells, and as such was selected for inclusion in the literature review because it contains detailed information on mobile source activities.

ENVIRON reviewed the complete FEIS document, as well as technical support documents filed by BLM for inclusion with the FEIS. These included air quality analysis reports prepared by TRC Environmental Corporation and SWCA Environmental Consultants as part of the FEIS process (TRC, 2006). ENVIRON also reviewed the Record of Decision (ROD) for the FEIS to determine if the final decision made by BLM in approving the FEIS mandated any changes that would impact the air quality analysis, and specifically the mobile source activity and emissions estimates presented under the Proposed Action. The ROD indicated that the Proposed Action was approved in the ROD, and thus the results and activity data presented below are for the Proposed Action only.

Geographic Scope

The project area covered approximately 30,500 acres located in portions of Townships 28 and 29 North, Ranges 107 through 109 West, approximately 32 miles southeast of Pinedale and 28 miles northwest of Farson, Wyoming. A map of the boundaries of the proposed infill drilling project is shown below in Figure 2.

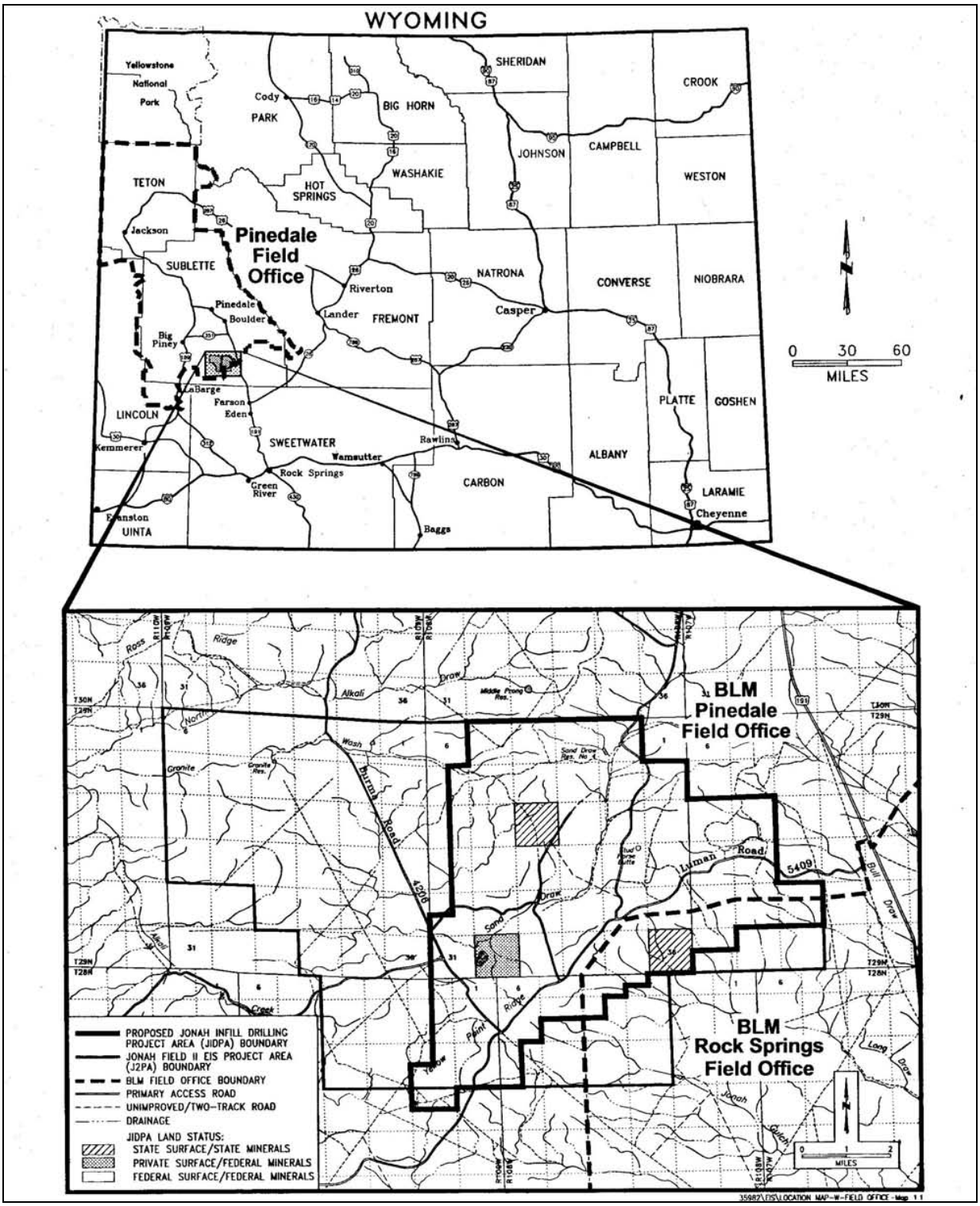

Figure 2. Geographic scope of the Jonah Infill Drilling FEIS (source: BLM, 2006).

The Jonah Field is a highly concentrated gas development area with significant potential gas reserves. The formation that is primarily accessed by oil and gas operators in the Jonah Field is sedimentary formation of approximately 12,000 foot depth or greater. Both natural gas and condensate are produced from this formation, and hydraulic fracturing is required to stimulate

wells for production. This FEIS assumed that no new infill wells drilled as part of the Proposed Action would be oil wells or CBM gas wells.

For purposes of estimating emissions from the Proposed Action, the FEIS analysis considered the Jonah Infill Drilling Project Area (JIDPA) to be the geographic domain. The JIDPA is limited to the field itself, and the paved and unpaved roadways associated with the field. Off-site mobile source emissions were not considered in the air quality analysis for the FEIS (although other off-site emissions from state permitted sources were considered).

Calendar Year

The Jonah Infill Drilling Project FEIS considered a series of calendar years from 2005 through 2017, with annual emissions estimates for each year in that period. Drilling projections, including the number of new wells drilled, total projected active wells and production projections were developed for each projected year in the analysis. This information was used for purposes of estimating total activity and the subsequent emissions inventory.

Source Categories

The Jonah Infill Drilling Project FEIS air quality analysis was developed considering distinct phases of development of the new infill wells. This included well pad construction, resource road construction, pipeline construction, completion activities, and production activities. These phases were considered separately for straight drilling and directional drilling. For each phase, both on-road and off-road sources were considered. On-road sources were primarily focused on heavy-duty trucks, but included some light-duty truck activity. Off-road equipment included standard construction equipment, and activity and emissions from the drilling rigs themselves. As noted above, this literature review does not include the drilling rigs as these are not within the scope of this study. The complete list of mobile source categories considered in the FEIS air quality analysis is shown below.

- Well Site Construction
    - Well Pad/Resource Road Construction
        - Scrapers
        - Graders
        - Dozers
    - Well Pad/Resource Road Traffic
        - Gravel/haul trucks
        - Light-duty pickup trucks
    - Pipeline Construction
        - Graders
        - Excavators
        - Trenchers
        - Tractors
    - Pipeline Construction Traffic
        - Semi/transport trucks
        - Boom trucks
        - Equipment trucks
        - Water trucks
        - Sand trucks
        - Gravel trucks
        - Light-duty pickup trucks
- Drilling
    - Rig Move and Drilling Traffic – Straight and Directional Drilling
        - Semi/tractor-trailer trucks
        - Mud trucks
        - Water trucks

        - Fuel trucks
        - Cement trucks
        - Logging trucks
        - Roustabouts
        - Welders
        - Contract labor
        - Vendors/marketers
- Completion
    - Completion/Testing Traffic
        - Transport trucks
        - Water trucks
        - Sand trucks
        - Fracing trucks
        - Large/small haul trucks
        - Light-duty pickup trucks
- Production
    - Production Traffic
        - Workover rigs
        - Haul trucks
        - Light-duty pickup trucks

Methodology

The project source emissions inventory was developed in accordance with the FEIS protocol and the Wyoming Department of Environmental Quality (WYDEQ) oil and gas inventory guideline. All activity and emissions were developed on a per-well basis or per unit production basis, and scaled to the number of projected wells or projected production for each analysis year.

Activity data and projected wells/production were primarily derived from information provided by the project applicants (oil and gas producers). This included the on-road and off-road mobile source activity associated with each of the phases of the development of the well, through the production phase. Activity data for off-road equipment obtained from the project applicants included the number of units of off-road equipment needed for different phases of roadway, well pad and pipeline construction, and the duration of the construction activities by equipment type and horsepower. Activity data for on-road vehicles obtained from the project applicants included the number of round trips required for different phases of the well development and subsequent production by truck type. For some on-road truck activity, the technical contractor responsible for the air quality analysis in the FEIS used maps of the field road network in the Jonah Field to estimate the mileage associated with trips to and from the well sites. It should be noted that vehicle travel outside of the JIDPA was not considered in the air quality analysis for the FEIS.

Activity data for on-road and off-road mobile sources were combined with emissions factors following the WDEQ guidance to estimate total emissions per well or per unit production. The results on a per-well basis were then scaled to total emissions for all wells in the JIDPA associated with various project alternatives considered in the FEIS, including reduced development and directional drilling alternatives.

Emissions Factor Sources

The FEIS air quality analysis exclusively used mobile source tailpipe and fugitive dust emissions factors from EPA's AP-42 guidance (EPA, 2009). This included both on-road and off-road source types. The specific emissions factors used in the FEIS analysis for different source types were provided in the technical appendices to the FEIS air quality section, and are presented below in Table 5 for fugitive dust and Table 6 for tailpipe emissions.

Table 5. Jonah Infill Drilling Project FEIS On-Road and Off-Road Fugitive Dust Emissions Factors.

Source Category	Vehicle Type	Road Type	Total Suspended Particulates (tons/acre-month)	Fugitive PM_{10} (lb/VMT)	Fugitive $PM_{2.5}$ (lb/VMT)	% of TSP in PM_{10}	% of TSP in $PM_{2.5}$	Efs AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b
Well Pad/Resource Road: Construction Fugitives	-	-	1.2	-	-	36	9.5	AP-42 (EPA 2004), Section 13.2.3, "Heavy Construction Operations"
Well Pad Unpaved Road: Unpaved Road Traffic Fugitives	Gravel/haul truck	Primary Road/Resource	-	1.54	0.24	-	-	X
	Light trucks/pickup trucks	Primary Road	-	0.56	0.08	-	-	X
		Resource	-	0.46	0.07	-	-	X
Rig Move and Drilling: Unpaved Road Traffic Fugitives	Semis-tractor/ trailer/mud/water/fuel/ cement trucks	Primary Road/Resource	-	1.7	0.26	-	-	X
						-	-	X
	Logging/mud trucks	Primary Road/Resource	-	1.77	0.27	-	-	X
	Roustabouts/welders / hot-shot/contract labor	Primary Road/Resource	-	1.19	0.18	-	-	X
	Vendors/marketers/ Various	Primary Road	-	0.56	0.083	-	-	X
		Resource	-	0.46	0.068	-	-	X
Completion Testing - Unpaved Road Traffic Fugitives	Semis/transport/ water/sand/frac trucks	Primary Road/Resource	-	1.87	0.29	-	-	X
	Large Haul Trucks	Primary Road/Resource	-	1.77	0.27	-	-	X
	Small Haul Trucks	Primary Road/Resource	-	1.19	0.18	-	-	X
	Light trucks/ pickups	Primary Road	-	0.56	0.08	-	-	X
		Resource	-	0.46	0.07	-	-	X
Pipeline Construction - Unpaved Road Traffic Fugitives	Semis/transport, boom, equipment, water removal, sand, and gravel trucks	Primary Road/Resource	-	1.87	0.29	-	-	X
	Light truck/pick-ups	Primary Road/Resource	-	0.23	0.03	-	-	X
Rig Move and Drilling – Straight and Directional Drilling - Unpaved Road	Semis-tractor/ trailer/mud/water/fuel/ cement trucks	Primary Road/Resource	-	1.7	0.26	-	-	X

Source Category	Vehicle Type	Road Type	Total Suspended Particulates (tons/acre-month)	Fugitive PM_{10} (lb/VMT)	Fugitive $PM_{2.5}$ (lb/VMT)	% of TSP in PM_{10}	% of TSP in $PM_{2.5}$	Efs AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b
Traffic Fugitives	Logging/mud trucks	Primary Road/Resource	-	1.77	0.27	-	-	X
	Roustabouts/welders / hot-shot/contract Labor	Primary Road/Resource	-	1.19	0.18	-	-	X
	Vendors/marketers/	Primary Road	-	0.56	0.083	-	-	X
	Various	Resource	-	0.46	0.068	-	-	X
Production Unpaved Road Traffic Fugitives	Workover Rig	Primary Road/Resource	-	2.35	0.36	-	-	X
	Haul trucks (water/condensate)	Primary Road/Resource	-	1.87	0.29	-	-	X
	Light trucks/	Primary Road	-	0.56	0.083	-	-	X
	pickups/pumpers8	Resource	-	0.46	0.068	-	-	
Construction and Production Wind Erosion (Efs: (lb/hr/100 m2))	-	-	-	0.3733	0.1493	-	-	AP-42 Chapter 13.2.5 (EPA 2004), Industrial Wind Erosion using Jonah Field, Wyoming meteorological data.

Table 6. Jonah Infill Drilling Project FEIS On-Road and Off-Road Tailpipe Emissions Factors.

Source Category	Equipment/Vehicle Type	Construction Emission Factor (g/hp-hr) and Haul Truck Emission Factors (grams/mile)					Emission Factor Source
		CO	NOx	SO_2	VOC	PM_{10}	
Well Pad/Resource Road Construction Equipment Combustion Emission Factors	Scraper	2.45	7.46	0.901	0.55	0.789	AP-42 (EPA 1985), Volume II Mobile Sources
	Motor Grader	1.54	7.14	0.874	0.36	0.625	AP-42 (EPA 1985), Volume II Mobile Sources
	D8 Dozer	2.15	7.81	0.851	0.75	0.692	AP-42 (EPA 1985), Volume II Mobile Sources, emission factor for track-type tractor.
Pipeline Construction Equipments	Grader	1.54	7.14	0.874	0.36	0.625	AP-42 (EPA 1985), Volume II Mobile Sources
	Excavator	2.15	7.81	0.851	0.75	0.692	AP-42 (EPA 1985), Volume II Mobile Sources, Emission factor for track-type tractor.
	Trencher	4.6	11.01	0.932	1.01	0.902	AP-42 (EPA 1985), Volume II Mobile Sources, Emission factor for miscellaneous.
	Tractor	7.34	11.91	0.851	1.76	1.27	AP-42 (EPA 1985), Volume II Mobile Sources, Emissions factor for wheeled tractor.
Haul Truck Tail Pipe	All	14.74	11.44	0.32	5.69	-	AP-42 (EPA 1985), Volume II Mobile Sources. Heavy duty diesel engine powered trucks, high altitude, 20 mph, "aged" with 50,000 miles, 1997+ model. The SO2 emission factor is calculated assuming 10 mpg fuel consumption, with 0.05% sulfur content of #2 diesel fuel, and fuel density of 7.001 lb/gal.

Results

The activity estimates for different on-road vehicle types for all well development phases considered in the FEIS analysis are presented below in Tables 7-10.

The activity estimates totaled over the different phases of well development estimated in the FEIS analysis indicate that approximately 1,050 truck round-trips per well/pad are required for all pre-production activities including well, road and pipeline construction, and well drilling and completion. For production, the FEIS assumes that supervisory control and data acquisition (SCADA) systems would reduce the number of site visits to the well by 30-40% over the lifetime of the well. This would lead to approximately 3,792-4,424 production-related truck round trips per well/pad over the 40-year lifetime of a well.

Emissions results indicate that approximately 0.49 ton of NOx emissions and approximately 0.12 ton of VOC emissions results from construction associated with a single well pad, including both on-road vehicles and off-road construction equipment. Production-related mobile source emissions total approximately 0.008 ton of NOx per well and 0.004 ton of VOC per well. Over the assumed 40-year lifetime of wells in the Jonah Infill Drilling Project, total production-related mobile source emissions range from 0.19-0.22 ton NOx per well and 0.10-0.11 ton VOC per well, depending on the SCADA effectiveness in trip reduction.

Table 7. Jonah Infill Drilling Project FEIS Summary of Activity Data for Construction Equipment, Construction Fugitives and Wind Erosion.

Type of Equipment	Engine Hp	No of Units of Equipments	Load Factor	Activity Duration (days/equip)	Activity Duration (hrs/day)	Area (acres)	Emission Control Efficiency (%)
Well Pad/Resource Road Construction							
Scraper	700	2	0.4	4	10	-	-
Motor Grader	250	1	0.4	4	10	-	-
D8 Dozer	210	1	0.4	2	10	-	-
Well Pad Construction Fugitives							
Fugitives	-	-	-	4*	10	3.8	50
Resource Road Construction Fugitives							
Fugitives	-	-	-	4*	10	1.3455	50
Pipeline Construction							
Grader	200	1	0.4	2	8	-	-
Excavator	300	1	0.4	4	8	-	-
Trencher	300	1	0.4	1	8	-	-
Tractor	150	1	0.4	2	8	-	-
Pipeline Construction Fugitives							
Fugitives	-	-	-	4*	8	0.45	50
Construction Wind Erosion							
Well Pad Construction	-	-	-	-	-	3.8	50
Resource Road Construction	-	-	-	-	-	1.3455	50
Pipeline Construction	-	-	-	-	-	0.45	50
Well Pad - Production	-	-	-	-	-	0.9	0

Table 8. Jonah Infill Drilling Project FEIS Summary of Activity Data for Road Traffic Fugitives.

Vehicle Type	Road Type	Dust Control Method	Average Vehicle Weight (lb)	Average Vehicle Speed (mph)	Round Trips (trips/pad or well)	Round Trip Distance (miles)	Vehicle Miles Traveled (VMT)	Emission Control Efficiency (%)	Still Content (%)	Moisture Content (%)
Well Pad/Resource Road Traffic										
Gravel/haul truck	Primary Road	Magnesium Chloride	35,000	20	8	14	112	85	5.1	2.4
	Resource	Water		15	8	5	40	50	5.1	2.4
Light trucks/pickup trucks	Primary Road	Magnesium Chloride	7,000	30	12	14	168	85	5.1	2.4
	Resource	Water		20	12	5	60	50	5.1	2.4
Rig Move and Drilling Traffic - Straight Drilling										
Semis-tractor/ trailer/mud/water/ fuel/cement trucks	Primary Road	Magnesium Chloride	44,000	20	140	14	1,960	85	5.1	2.4
	Resource	Water		15	140	5	700	50	5.1	2.4
Logging/mud trucks	Primary Road	Magnesium Chloride	48,000	20	10	14	140	85	5.1	2.4
	Resource	Water		15	10	5	50	50	5.1	2.4
Roustabouts/welders / hot-shot/contract Labor	Primary Road	Magnesium Chloride	20,000	30	20	14	280	85	5.1	2.4
	Resource	Water		20	20	5	100	50	5.1	2.4
Vendors/marketers/ Various	Primary Road	Magnesium Chloride	7,000	30	30	14	420	85	5.1	2.4
	Resource	Water		20	30	5	150	50	5.1	2.4
Completion/Testing Traffic										
Semis/transport/ water/sand/frac trucks	Primary Road	Magnesium Chloride	54,000	20	350	14	4,900	85	5.1	2.4
	Resource	Water		15	350	5	1,750	50	5.1	2.4
Large Haul Trucks	Primary Road	Magnesium Chloride	48,000	20	50	14	700	85	5.1	2.4
	Resource	Water		15	50	5	250	50	5.1	2.4
Small Haul Trucks	Primary Road	Magnesium Chloride	20,000	30	30	14	420	85	5.1	2.4
	Resource	Water		20	30	5	150	50	5.1	2.4
Light trucks/ pickups	Primary Road	Magnesium Chloride	7,000	30	140	14	1,960	85	5.1	2.4
	Resource	Water		20	140	5	700	50	5.1	2.4
Pipeline Construction										
Semis/transport, boom, equipment, water removal, sand, and gravel trucks1	Primary Road	Magnesium Chloride	54,000	20	8	14	112	85	5.1	**2.4**
	Resource	Water		15	8	5	40	50	5.1	**2.4**
Light truck/pick-ups	Primary Road	Magnesium Chloride	7,000	30	12	14	168	85	5.1	**2.4**
	Resource	Water		20	12	5	60	50	5.1	**2.4**
Rig Move and Drilling Traffic – Directional Drilling										
Semis-tractor/ trailer/mud/water/	Primary Road	Magnesium Chloride	44,000	20	168	14	2,352	85	5.1	**2.4**

Vehicle Type	Road Type	Dust Control Method	Average Vehicle Weight (lb)	Average Vehicle Speed (mph)	Round Trips (trips/pad or well)	Round Trip Distance (miles)	Vehicle Miles Traveled (VMT)	Emission Control Efficiency (%)	Still Content (%)	Moisture Content (%)
fuel/cement trucks	Resource	Water		15	168	5	840	50	5.1	**2.4**
Logging/mud trucks	Primary Road	Magnesium Chloride	48,000	20	12	14	168	85	5.1	**2.4**
	Resource	Water		15	12	5	60	50	5.1	**2.4**
Roustabouts/welders / hot-shot/contract Labor	Primary Road	Magnesium Chloride	20,000	30	24	14	336	85	5.1	**2.4**
	Resource	Water		20	24	5	120	50	5.1	**2.4**
Vendors/marketers/ Various	Primary Road	Magnesium Chloride	7,000	30	36	14	504	85	5.1	**2.4**
	Resource	Water		20	36	5	180	50	5.1	**2.4**
Production Traffic*										
Workover Rig	Primary Road	Magnesium Chloride	90,000	20	1	14	14	85	5.1	**2.4**
	Resource	Water		15	1	5	5	50	5.1	**2.4**
Haul trucks (water/condensate)	Primary Road	Magnesium Chloride	54,000	20	35	14	490	85	5.1	**2.4**
	Resource	Water		15	35	5	175	50	5.1	**2.4**
Light trucks/ pickups/pumpers8	Primary Road	Magnesium Chloride	7,000	30	122	14	1,708	85	5.1	**2.4**
	Resource	Water		20	122	5	610	50	5.1	**2.4**

*Activity for production is number of round trips per year

Table 9. Jonah Infill Drilling Project FEIS Summary of Activity Data for Heavy Equipment Tailpipe Emissions Estimates.

Activity	Total Haul Truck Round Trip (trips/well)	Round Trip Distance (miles/trip)	Total Haul Truck Miles Traveled (miles/well)	Haul Activity Duration (days/well)	Haul Activity Duration (hrs/day)
Well Pad Construction	Included under well pad construction equipment				
Rig Move and Drilling Haul Truck Tailpipe - Straight Drilling	170	19	3,230	22	24
Completion/Testing Heavy Equipment Tailpipe	430	19	8,170	35	17
Pipeline Heavy Equipment Tailpipe	Included under well pad construction equipment				
Rig Move and Drilling Haul Truck Tailpipe - Directional Drilling	216	19	4,104	26	24
Production Heavy Equipment Tailpipe (activity per year)	35	19	665	-	-

Table 10. Jonah Infill Drilling Project FEIS Summary of Tailpipe and Fugitive Dust Emissions.

Source Category	CO (lb/well)	NOx (lb/well)	SO_2 (lb/well)	VOC (lb/well)	PM_{10} (lb/well)	Fugitive PM_{10} (lb/well or pad)	Fugitive $PM_{2.5}$ (lb/well or pad)
Well Pad Construction Fugitives	-	-	-	-	-	218.88	57.76
Resource Road Construction Fugitives	-	-	-	-	-	77.50	20.45
Well Pad and Resource Road Construction: Unpaved Road Traffic Fugitives	-	-	-	-	-	84.27	12.81
Well Pad/Resource Road Construction Equipment: Tailpipe Emissions	142.53	460.28	55.35	33.11	47.04	-	-
Rig Move and Drilling - Straight Drilling: Unpaved Road Traffic Fugitives	-	-	-	-	-	1,356.90	207.79
Rig Move and Drilling - Straight Drilling: Unpaved Road Tailpipe Emissions	104.96	81.46	2.26	40.52	-	-	-
Rig Move and Drilling- Directional Drilling: Unpaved Road Traffic Fugitives	-	-	-	-	-	1,628.28	249.34
Rig Move and Drilling- Directional Drilling: Unpaved Road Traffic Tailpipe Emissions	133.36	103.50	2.87	51.48	-	-	-
Completion Testing : Unpaved Road Traffic Fugitives	-	-	-	-	-	3,900.91	596.87
Completion Testing : Unpaved Road Traffic Tailpipe Emissions	265.49	206.05	5.72	102.49	-	-	-
Pipeline Construction Fugitives	-	-	-	-	-	52.36	13.82
Pipeline Construction: Unpaved Road Traffic Fugitives	-	-	-	-	-	81.39	12.42
Pipeline Construction: Heavy Equipment Tailpipe Emissions	47.82	134.77	13.44	13.23	12.22	-	-
Construction Wind Erosion (lb/hr)	-	-	-	-	-	42.26	16.91
Production: Unpaved Road Traffic Fugitives	-	-	-	-	-	593.49	89.90
Production: Unpaved Road Tailpipe (annual emissions per well)	21.6	16.78	0.48	8.34	-	-	-
Production Wind Erosion (lb/hr)	-	-	-	-	-	13.60	5.44

Uncertainty/Error Analysis

The FEIS did not present any uncertainty or error analysis. All estimates for on-road and off-road activities associated with each phase of well development were presented as individual values, without specifying a range of values or uncertainty. This is expected for the analysis requirements of a National Environmental Policy Act (NEPA) document.

The only range of activities presented is for the variation in truck and construction equipment activity associated with straight drilling and directional drilling.

Northern San Juan Basin CBM Project EIS

The Northern San Juan Basin CBM Project Final EIS (NSJBCBM FEIS) is the environmental impact analysis document for a proposed project to develop CBM wells in the North San Juan Basin in Southwestern Colorado. The project was proposed by a group of oil and gas producers acting collectively as applicants to the BLM.

The project consists of drilling of 185 CBM wells and setting up ancillary facilities required to support them to develop federal gas leases in this area. The applicants proposed to drill these CBM wells on federal mineral estate leases within the Northern San Juan Basin Project Area. In the project plan proposed to the Forest Service and BLM the operators requested for waiver, exception, or modification of certain lease stipulations on five federal oil and gas leases issued in 2001. The EIS was prepared to analyze and disclose potential environmental consequences of authorizing the operators to proceed with their proposal. Approximately 12,500 conventional and CBM wells have been constructed throughout the project area up to the period of time of the study.

The EIS analyzed a total of five alternatives, including No Action, Proposed Action, Maximum Development, and Preferred Action alternatives in detail. The preferred alternative (the Proposed Action) was adopted in 2007 in the Record of Decision with a few modifications in which the responsible official would not approve the operators' proposal to develop CBM in areas of the HD Mountains (Turkey Creek, Goose Creek, Ignacio Canyon, Bull Creek and Green Creek areas) where access roads overlay areas with high potential for landslides and mass wasting.

Geographic Scope

The proposed development included a 125,000-acre project area in the Northern San Juan Basin (NSJB) of Colorado that is bounded by the Southern Ute Reservation to its south, and to the west, north, and east by the outcrop at the top of the Fruitland Coal Formation. The Project area includes portions of both La Plata and Archuleta Counties in Colorado. The boundaries of the project are shown in Figure 3 below.

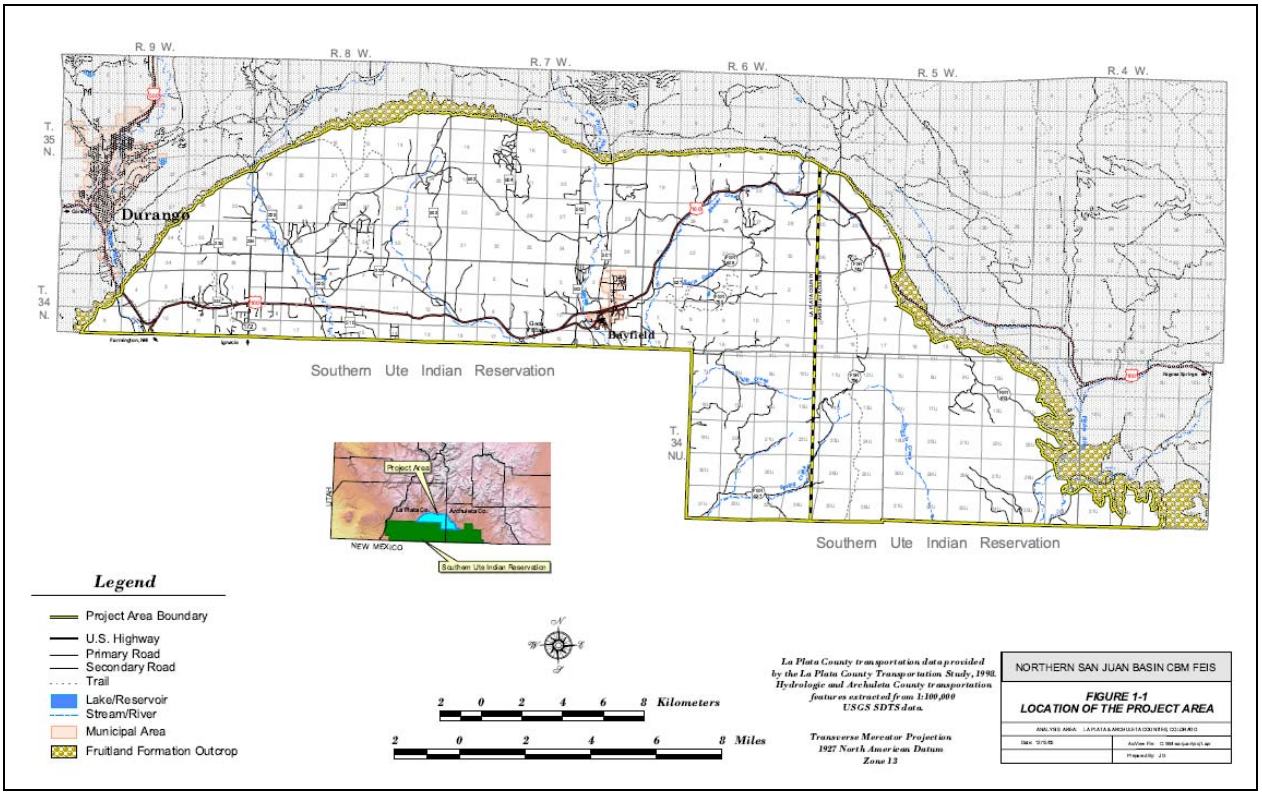

Figure 3. Geographic scope of the North San Juan Basin CBM Project EIS (source: USFS, 2006).

The Project would involve drilling of 185 CBM wells on federal land (a total of 284 CBM wells) accessing the Fruitland Coal formation, which has already been the focus of previous CBM gas development. Wells accessing this formation were estimated to have a lifetime of 25 to 30 years. The entire project area lies just outside the boundaries of the Southern Ute Indian Tribe (SUIT) land. The preferred alternative also included the development of 97 miles of access roads within the project area and 6 miles of pipeline within the project area.

The FEIS air quality technical support documentation did not provide sufficient details on the assumptions used in development of the FEIS to determine the exact geographic scope of the emissions analysis. It is assumed from the data presented in the FEIS that mobile source activity was tracked only within the project boundaries, and specifically only for the new road construction associated with the additional 185 CBM wells proposed in the preferred alternative.

Calendar Year

The NSJBCBM FEIS was analyzed assuming that drilling for new wells would begin in 2006, with a 5-year drilling duration. Given the estimated 25 to 30 year lifetime of wells, the FEIS analyzed the period 2006-2040.

Source Categories

The NSJBCBM FEIS considered a number of on-road vehicle and off-road equipment types used in the construction of well pads, resource roads and ancillary facilities (compressor stations), and drilling and completion activities. The FEIS also considers on-road traffic associated with operations including well workovers and trucking of water from well sites. The complete list of source categories considered in the FEIS is listed below:

- Access Road and Well Pad Construction
    - Haul trucks
    - Gravel trucks

    - Flatbed trucks
- Well Installation
    - Well drilling
        - Rig truck
        - Support truck
        - Casing tong truck
        - Water truck
        - Mud truck
        - Fuel truck
        - Worker vehicles
        - Rig mechanic truck
        - Casing haul truck
        - Cement truck
        - Bulk truck
        - Logging truck
        - Miscellaneous trucks
    - Well completion and testing
        - Completion rig
        - Completion equipment truck
        - Worker vehicles
        - Tubing trucks
        - Service tools
        - Loggers truck
        - Fracing Unit
        - Blender
        - Chemical truck
        - Sand truck
        - Manifold truck/trailer
        - Instrument van
        - Miscellaneous trucks
    - Well Site Facilities Installation/Pipeline Installation
        - Worker vehicles
        - Welder trucks
        - Water trucks
        - Haul trucks
        - Dump trucks
- Well Operation
    - Well Workover
        - Worker vehicles
        - Pusher truck
        - Pumper truck
    - Compressor Site Installation And Operations
        - Tractor/trailer
        - Cement truck
        - Gang truck
        - Welding truck
        - Worker vehicles
    - Produced Water Collection By Truck
        - Water truck

It should be noted that although off-road equipment associated with construction of well pads, resource roads and compressor stations is cited in the FEIS and included in the presentation of

emissions rates from these activities, the detailed list of off-road construction equipment including equipment parameters (e.g. number, horsepower, load factor, etc.) is not presented.

Instead the FEIS cites the construction analysis developed as part of the earlier Southern Ute Indian Tribe Coal Bed Methane Gas Field Expansion Project Environmental Impact Statement, published in October 2000.

Methodology

The FEIS gathered data primarily from oil and gas producers who were collectively the applicants for this project. The FEIS did not specifically cite the sources of emissions factor data but rather referenced the older Southern Ute CBM Expansion Project EIS.

The FEIS basic methodology was to develop estimates of the number of on-road vehicle trips by vehicle type needed for each phase of the well development, on a per-well basis. The mileage of travel per trip and the speed were used to develop estimates of the travel time per trip per vehicle type, and this was combined with emissions factor data to estimate the emissions rates from all activities (lb/hr). The total duration of different activities was also provided, although the total emissions were not explicitly provided in the FEIS air quality technical support document. ENVIRON used the emissions rates and the duration of activities to develop estimates of the total per-well emissions associated with different well development phases.

Emissions Factor Sources

The NSJBCBM FEIS did not explicitly cite the emissions factor sources used to develop the estimates of emissions rates for different phases of well development. The FEIS only cited the previous SUIT CBM Expansion Project EIS from 2000 as the reference for these emissions. The SUIT CBM Expansion Project EIS used AP-42 emissions factors (EPA, 2009) to develop estimates of on-road vehicle and off-road equipment emissions. The combined emissions rates per well for the various well development activities considered in the NSJBCBM FEIS are presented below in Tables 11-13. It should be noted that these emissions rates are a combination of the emissions factors on a per-unit equipment basis, and the assumed specifications and activity for this equipment.

Table 11. NSJBCBM Project Well Pad Site and Resource Road Construction Phase Emission Rates.

Activities	Emission Rates (lb/hr)				
	PM_{10}	SO_2	NOx	CO	VOC
FUGITIVE DUST EMISSIONS					
Well pad construction	2.62	0.00	0.00	0.00	0.00
Resource road construction	3.15	0.00	0.00	0.00	0.00
Traffic on unpaved haul roads	37.83	0.00	0.00	0.00	0.00
Subtotal	43.60	0.00	0.00	0.00	0.00
EQUIPMENT AND VEHICLE EMISSIONS					
Truck tail pipe emissions	0.91	1.01	10.87	3.17	0.95
Heavy construction equipment	0.31	0.24	3.04	1.24	0.38
Subtotal	1.22	1.25	13.91	4.41	1.33
Maximum Hourly Emissions	44.82	1.25	13.91	4.41	1.33

Table 12. NSJBCBM Project Well Site Rig-Up, Drill and Rig-Down Phase Emission Rates.

Activities	Emission Rates (lb/hr)				
	PM_{10}	SO_2	NOx	CO	VOC
Traffic on unpaved haul roads	25.34	0.00	0.00	0.00	0.00
Subtotal	25.34	0.00	0.00	0.00	0.00
Truck tail pipe emissions	0.67	0.75	8.09	2.36	0.71
Operation of drill rig engines	1.07	1.02	15.11	3.27	1.22
Subtotal	1.74	1.77	23.20	5.63	1.93

Maximum Hourly Emissions	27.08	1.77	23.20	5.63	1.93

Table 13. NSJBCBM Project Well Completion and Testing Phase Emission Rates.

Activities	Emission Rates (lb/hr)				
	PM_{10}	SO_2	NOx	CO	VOC
Traffic on unpaved haul roads	11.25	0.00	0.00	0.00	0.00
Subtotal	11.25	0.00	0.00	0.00	0.00
Tail pipe emissions from trucks	0.16	0.18	1.94	0.57	0.17
Gas flaring	0.18	Neg.	2.02	11.01	1.88
Subtotal	0.34	0.18	3.96	11.58	2.05
Maximum Hourly Emissions	11.59	0.18	3.96	11.58	2.05

Results

Results from the NSJBCBM Project FEIS analysis of mobile sources are presented below. Two types of data are included in the results: (1) summary activity data for on-road vehicles in terms of trips per well for different phases of well development; and (2) summary emissions per well. The summary emissions, as noted in the methodology section above, were developed by ENVIRON using the emission rates presented in the FEIS and the duration of well activities listed in the FEIS. However the FEIS does not explicitly present these emissions. It should be noted that emissions factors and activity associated with off-road construction equipment was not available in the FEIS, only the emissions rates. These rates were used to estimate total emissions from off-road construction activities. Table 14 below summarizes the activity data for on-road vehicles, and Table 15 summarizes the per well emissions estimated from the activity data.

Table 14. NSJBCBM Project Summary of On-Road Vehicle Trips for Well Development Activities.

Facility/Activity	Frequency of Trips (trips/well)
Access Road and Well Pad Construction	
Haul Truck for Dozer	2
Haul Truck for Grader	2
Haul Truck for Backhoe	2
Gravel Truck (20 Yard)	200/mile of road
Flatbed Truck for Rig-Up, Rig-Down	50
Well Installation	
Well Drilling	
Truck Mounted Rig	1
Support Trucking	32
Casing Tong Truck	1
Water Truck	25
Mud Truck	3
Fuel Truck	2
Rig Crews/Pick-Up	3/day
Rig Mechanic/Truck	1
Proponent Supervisor/Pick-Up	2/day
Mud Engineers Truck	1/day
Casing Haul Truck	2
Cementers/Pick-Up	2
Bulk Truck	3
Loggers/Logging Truck	1
Loggers, Engineers Car	1
Misc. Supplies/Pick-Up	2
Well Completion And Testing	

Facility/Activity	Frequency of Trips (trips/well)
Completion Unit/Rig	1
Completion Equipment Truck	1
Completion, Crew Pick-Up	12
Completion Pusher	3
Proponent Supervisor	2
Tubing Trucks	1
Service Tools	2
Loggers/Truck	1
Loggers/Car	1
Anchor Installation	1
Frac Unit	1
Sand Storage Bin	1
Blender	1
Chemical Truck	1
Sand Truck	9
Manifold Truck	1
Manifold Trailer	1
Instrument Van	2
Misc. Supplies Pick-Up	4
Well Site Facilities Installation	
Roustabout Crew Truck	2
Welder Truck	5
Water Truck	24
Gathering Pipelines Installation	
Haul Truck for Dozer	2/mile of flowline
Haul Truck for Ditcher	1/mile
Haul Truck for Side Boom	4/mile
Haul Truck for Track Hoe	2/mile
Crew Pickups	21/mile
10 Yard Dump Trucks for Padding	117/mile
Haul Truck - Pipe and Materials	3/mile for 4-inch Pipe
	8/mile for 20-inch Pipe
Well Operations	
Well Workover	
Service Unit	1
Service Unit Crew Pick-Up	2
Pusher Truck	1
Proponent Supervisor Pick-Up	1
Pumper Pick-up	1/well/day
Compressor Site Installation And Operations	
Installation	
Tractor Truck	8/site
Trailer	4/site
Cement Truck	4/site
Gang Truck	30/site
2 Welding Trucks	30/site
Pick-Up	100/site
Operations	
Pick-Up	2/day
Gang Truck	1/week
Water Truck	2/month
Produced Water Collection By Truck	
Water Truck	5/month (Average)

Table 15. NSJBCBM Project Summary Mobile Source Emissions for Well Development.

Activities	Emission Rates (lb/well)				
	PM_{10}	SO_2	NOx	CO	VOC
Well Pad Site and Resource Road Construction Phase: Fugitive Dust					
Well pad construction	62.88	0	0	0	0
Resource road construction	75.6	0	0	0	0
Traffic on unpaved haul roads	907.92	0	0	0	0
Well Pad Site and Resource Road Construction Phase: Equipment and Vehicle					
Truck tail pipe emissions	21.84	24.24	260.88	76.08	22.8
Heavy construction equipment	7.44	5.76	72.96	29.76	9.12
Well Site Rig-Up, Drill and Rig-Down Phase					
Traffic on unpaved haul roads (fugitive dust)	1621.76	0	0	0	0
Truck tail pipe emissions	42.88	48	517.76	151.04	45.44
Operation of drill rig engines	154.08	146.88	2175.84	470.88	175.68
Well Completion and Testing Phase					
Traffic on unpaved haul roads (lb/equipment operation, fugitive dust)	2250	0	0	0	0
Tail pipe emissions from trucks (lb/equipment operation)	32	36	388	114	34

Uncertainty/Error Analysis

The NSJBCBM FEIS does not include any analysis of uncertainty or error in the estimates of mobile source activity or emissions. The FEIS analysis does not provide ranges of activity values per well, and provides only a single value per activity type and per equipment type.

BLM Little Snake Field Office Draft Resource Management Plan

In January of 2007 the BLM Little Snake Field Office (LSFO) released a draft EIS to assess the environmental impacts of resource management plans for the LSFO RMP planning area. The LSFO administers 4.2 million acres of land in Moffatt, Routt, and Rio Blanco Counties in Northwestern Colorado in the Piceance Basin. The RMP planning area includes 1.3 million acres of public lands and mineral leases administered by the LSFO, and 1.1 million acres of private or state land with mineral leases also administered by the LSFO. The RMP and associated EIS cover only the public lands and federal mineral leases within the RMP planning area, and not mineral leases administered by other government agencies such as the U.S. Forest Service, the U.S. National Park Service or the U.S. Fish and Wildlife Service.

The Air Quality Technical Support Document (AQTSD) that accompanied the draft EIS (ENVIRON, 2008) analyzed the air quality and air quality related values (AQRVs) resulting from assumed air emissions due to hypothetical oil and gas development within the RMP area for a total of four different alternatives including: (1) Alternative A, the No Action Alternative; (2) Alternative B, the full development alternative; (3) Alternative C, the preferred development alternative; and (4) Alternative D, the minimal development alternative. The No Action Alternative was developed considering the Reasonable Foreseeable Development (RFD) scenario for the LSFO RMP planning area, assuming continued oil and gas activity without any additional actions on the part of the BLM. The RFD scenario analysis predicted that approximately 3,031 oil and gas wells would be drilled during the time period of the RMP analysis. Alternatives B, C and D also assumed this same level of development, and only assumed differences in land use unrelated to the level of oil and gas development. Alternative D, the minimal development alternative, assumed 75% of the new wells predicted under the other alternatives.

The RMP EIS analyzed the development of both oil and gas leases. Past development in this region includes both shale gas and tight sands gas exploration and production, and historic oil production (primarily concentrated in Rio Blanco County).

Geographic Scope

The 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).

The analysis area covered the majority of Moffat and Routt counties in northwest Colorado, a portion of northeast Rio Blanco County 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. It includes approximately 1.3 million acres of BLM-administered public lands and 1.1 million acres of federally-owned mineral estate. Figure 4 below shows a map of the BLM LSFO RMP planning area.

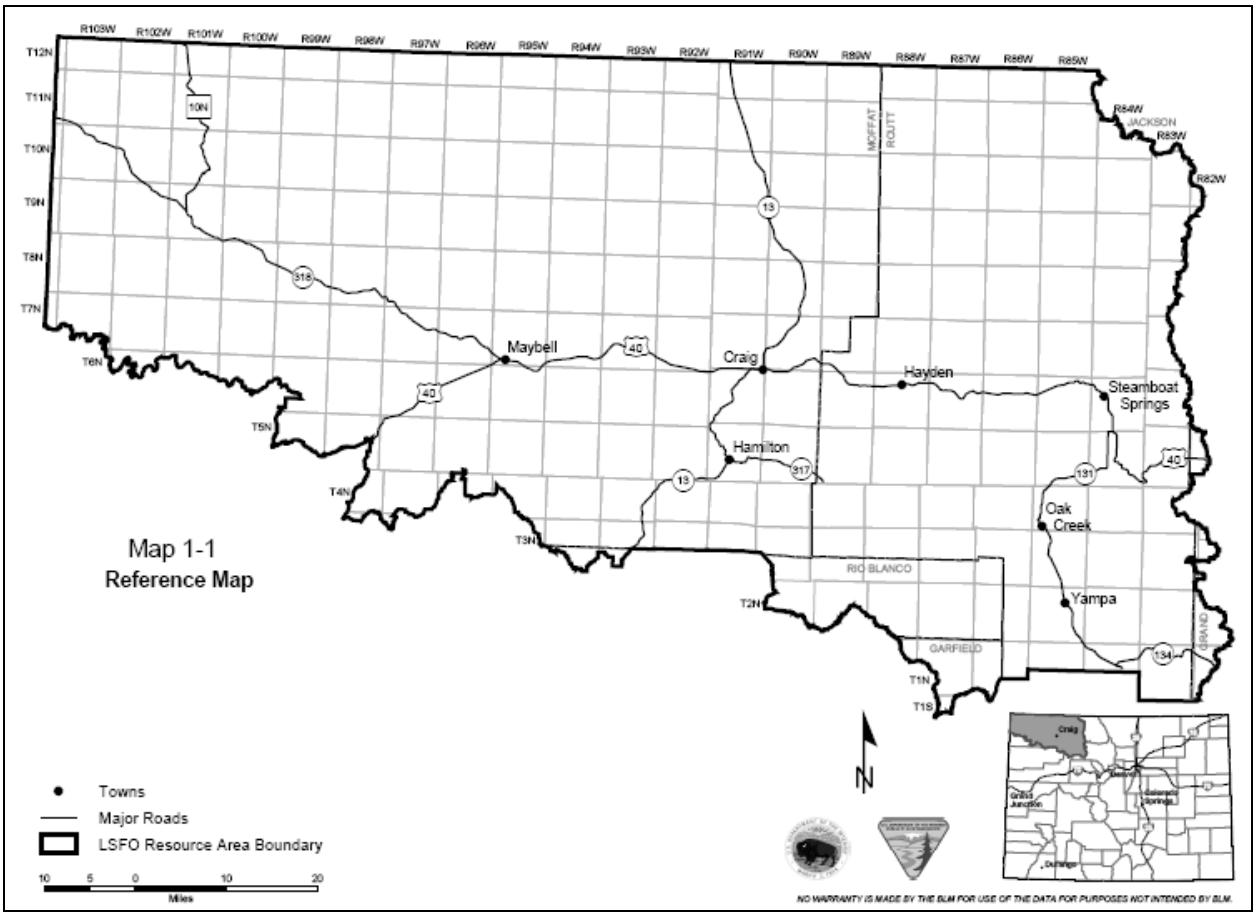

Figure 4. BLM LSFO RMP planning area in Northwestern Colorado (source: BLM, 2008).

As noted above, the oil and gas development area covered by the LSFO RMP EIS analysis includes both gas and oil development areas. Gas development includes tight sands gas and shale gas formations primarily located in the northern portion of Moffatt and Routt Counties (Bar-Ilan, et al., 2009). The northeastern portion of the planning area in Routt and Moffatt counties borders on the Green River Basin, and by USGS definitions is identified as part of the Green River Basin. There are some active oil wells in Moffatt and Routt Counties, but very little oil production in the portion of Rio Blanco County included in the LSFO geographic domain.

Calendar Year

The LSFO RMP EIS considered the RFD scenario put forward in 2005 by the BLM. The scenario called for development over a period of 20 years, beginning in 2005. The average life of a well is expected to be 40 years, therefore the maximum time period covered by the analysis is 2005-2065.

Source Categories

The LSFO RMP EIS analyzed a wide variety of emissions sources associated with oil and gas exploration, well development and subsequent production, including the installation of centralized facilities like compressor stations. The analysis included explicit presentation of the mobile source components of this activity, including off-road construction equipment and on-road vehicle traffic. A complete list of the mobile source categories considered in the air quality analysis of the EIS is listed below.

- Well Site Construction
    - Drilling and production roads
        - Backhoes
        - Blades
        - Semi trucks
    - Drilling and well pad construction (including wellhead compressor installation)
        - Backhoes
        - Dozers
        - Semi trucks
        - Haul trucks
        - Light-duty pickup trucks
    - Pipeline construction
        - Blades
        - Trenchers
        - Backhoes
        - Haul trucks
        - Light-duty pickup trucks
    - Central compressor station construction
        - Dozers
        - Backhoes
        - Semi trucks
        - Haul trucks
        - Light-duty pickup trucks
    - Electric line installation
        - Haul trucks
        - Light-duty pickup trucks
    - Drilling (rig up, drilling, and rig down)
        - Semi trucks (rig transport)
        - Fuel truck
        - Mud truck
        - Water truck
        - Light-duty pickup trucks (worker commutes)
        - Rig mechanics
        - Engineering trucks
    - Completion
        - Semi trucks
        - Blender truck

        - Fracing truck
        - Tubing truck
        - Cement truck
        - Pump truck
        - Equipment truck
        - Logging truck
        - Chemical truck
        - Sand truck
        - Water truck
        - Welding truck
        - Light-duty pickup trucks (worker commutes)
    - Natural gas production road traffic
        - Haul trucks
        - Light-duty pickup trucks
        - Graders
    - Oil production road traffic
        - Haul trucks
        - Light-duty pickup trucks
        - Graders
        - Tanker trucks

Note that workover rigs were included in the analysis but are not listed here as they are not part of the scope of the Piceance Basin pilot study. Workover rigs and drill rigs have been included in the scope of the WRAP Phase III emissions inventories (Bar-Ilan, et al., 2009).

Methodology

Data on equipment counts, equipment specifications and the activity of the equipment, including the acreage of disturbed land for fugitive dust calculations, associated with all of the development phases of oil and gas wells were obtained by the LSFO through a survey process. The LSFO surveyed major oil and gas production companies in operation in the region covered by the LSFO RMP EIS, compiled the data and aggregated the results to derive average per-well, per-station or per-project activity. In some cases engineering or technical judgment was used to gap-fill data where surveys did not provide sufficient data to use in the air quality analysis.

The activity and equipment data were combined with emissions factors to generate per well, per station or per project emissions. Total emissions inventories were then derived for various scenarios by scaling the per-well, per station or per-project emissions by the appropriate total count of each respective activity surrogate.

Emissions Factor Sources

The LSFO RMP EIS exclusively utilized the EPA's AP-42 emissions factors (EPA, 2009) for on-road and off-road vehicle tailpipe and fugitive dust emissions. This included emissions on a per-brake-horsepower basis for off-road construction equipment, and emissions on a per-mile traveled basis for light-duty and heavy-duty on-road trucks. Similarly, fugitive dust emissions factors used were on a per-acre disturbed basis for heavy-duty construction equipment and per-vehicle mile traveled for on-road vehicles.

Results

Results of the mobile source component of the LSFO RMP EIS emissions inventory analysis are presented below. This includes both the aggregated per-well, per-station or per-project activity data compiled through the survey process and the resulting per well, per station or per project emissions inventories.

Table 16. LSFO RMP EIS Activity Data for Off-Road Construction Equipment.

Construction Site	Equipment Type	Capacity (hp)	# of Units	Av. Load Factor (%)	Hours of Operation Per Day	Days of Operation (per well, station)	Total Hours of Operation (per well/station)
Construction Equipment							
Drill Roads	Blade	100	1	80	10	3	30
	Backhoe	80	1	75	10	3	30
Producing Roads	Blade	100	1	80	10	3	30
	Backhoe	80	1	75	10	3	30
Drilling Well Pad	Backhoe	80	1	75	10	2	20
Producing Well Pad	Backhoe	80	1	75	10	2	20
New Pipeline	Blade	100	1	80	10	1	10
	Trencher	175	1	80	10	1	10
	Backhoe	80	1	75	10	1	10
Well Head Compressor	Dozer	350	1	80	8	2	16
	Backhoe	80	2	80	8	2	16
Central Compressor Station	Dozer	350	1	80	8	2	16
	Backhoe	80	2	80	8	2	16
Maintenance Equipment for Natural Gas Wells							
Maintenance	Grader	135	1	-	-	-	8,729
Maintenance Equipment for Conventional Oil Wells							
Maintenance	Grader	135	1	-	-	-	1,745

Table 17. LSFO RMP EIS Activity Data for On-Road Traffic.

Construction Site Destination	Vehicle Type	Av. Vehicle Weight (lb)	Vehicle Class	Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station for Fugitive Dust	Miles Traveled per Well Pad or per Station for Fugitive Dust	# of Round Trips per Well Pad or per Station for Tailpipe	Miles Traveled per Well Pad or per Station for Tailpipe
Construction Road Traffic								
Drilling Roads	Semi Trucks	60,000	HDDV	6	2	12	2	12
Producing Roads	Semi Trucks	60,000	HDDV	6	2	12	2	12
Drilling Well Pad	Haul Trucks	45,000	HDDV	6	2	12	2	12
	Pickup Trucks	7,000	LDGT2	6	2	12	2	12
Producing Well Pad	Haul Trucks	45,000	HDDV	6	2	12	2	12
	Pickup Trucks	7,000	LDGT2	6	2	12	2	12
New Pipeline	Haul Trucks	45,000	HDDV	6	2	12	2	12
	Pickup Trucks	7,000	LDGT2	6	2	12	2	12
Electric Line	Haul Trucks	45,000	HDDV	6	2	12	2	12
	Pickup Trucks	7,000	LDGT2	6	2	12	2	12
Well Head Compressors	Semi Trucks	60,000	HDDV	6	2	12	2	12
	Haul Trucks	45,000	HDDV	6	2	12	2	12
	Pickup Trucks	7,000	LDGT2	6	2	12	2	12
Central Compressor Station	Semi Trucks	60,000	HDDV	6	2	12	2	12
	Haul Trucks	45,000	HDDV	6	2	12	2	12
	Pickup Trucks	7,000	HDDV	6	2	12	2	12
Rig-up, Drilling, and Rig-down	Semi Rig Transport & Drill Rig	80,000	HDDV	6	5	30	12	72
	Fuel Haul Truck	50,000	HDDV	6	5	30	12	72
	Mud Haul Truck, Water Hauling	60,000	HDDV	6	5	30	12	72
	Rig Crew	7,000	LDGT2	6	5	30	12	72
	Rig Mechanics	12,000	HDDV	6	5	30	12	72
	Co. Supervisor	7,000	LDGT2	6	5	30	12	72
	Tool Pusher	7,000	LDGT2	6	5	30	12	72

Construction Site Destination	Vehicle Type	Av. Vehicle Weight (lb)	Vehicle Class	Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station for Fugitive Dust	Miles Traveled per Well Pad or per Station for Fugitive Dust	# of Round Trips per Well Pad or per Station for Tailpipe	Miles Traveled per Well Pad or per Station for Tailpipe
	Mud Logger	7,000	LDGT2	6	5	30	12	72
	Mud Engineer	7,000	LDGT2	6	5	30	12	72
	Logger, Engr Truck	45,000	HDDV	6	5	30	12	72
	Drill Bit Delivery	7,000	LDGT2	6	5	30	12	72
	Semi Casing Haulers	60,000	HDDV	6	2	12	6	36
	Semi Completion, Unit Rig	120,000	HDDV	6	8	48	20	120
	Semi Fracing Blender	85,000	HDDV	6	2	12	4	24
	Semi Pumping Tank Battery	80,000	HDDV	6	2	12	6	36
	Tubing Truck	60,000	HDDV	6	2	12	6	36
	Haul Cementer, Pump Truck	85,000	HDDV	6	2	12	6	36
	Haul Cementer, Cement Truck	60,000	HDDV	6	8	48	6	36
	Haul Completion, Equip Truck	45,000	HDDV	6	2	12	20	120
	Haul Service Tools	7,000	LDGT2	6	2	12	6	36
	Haul Perforators Logging Truck	45,000	HDDV	6	2	12	6	36
	Haul Anchor Installation	40,000	HDDV	6	2	12	6	36
	Haul Anchor Testing	12,000	HDDV	6	2	12	6	36
	Haul Fracing Tank	40,000	HDDV	6	2	12	4	24
	Haul Fracing Pump	85,000	HDDV	6	2	12	4	24
	Haul Fracing Chemical	45,000	HDDV	6	2	12	4	24
	Haul Fracing Sand	60,000	HDDV	6	2	12	4	24
	Haul Fracing Other	85,000	HDDV	6	2	12	4	24
	Haul Welders	12,000	HDDV	6	2	12	4	24
	Haul Water Truck	60,000	HDDV	6	8	48	20	120
Well Completion & Testing	Pickup Cementer, Engineer	7,000	LDGT2	6	2	12	6	36

Construction Site Destination	Vehicle Type	Av. Vehicle Weight (lb)	Vehicle Class	Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station for Fugitive Dust	Miles Traveled per Well Pad or per Station for Fugitive Dust	# of Round Trips per Well Pad or per Station for Tailpipe	Miles Traveled per Well Pad or per Station for Tailpipe
	Pickup Chasing Crew	10,000	HDDV	6	2	12	6	36
	Pickup Completion Crew	10,000	HDDV	6	8	48	20	120
	Pickup Completion Pusher	7,000	LDGT2	6	8	48	20	120
	Pickup Perforators Engineer	7,000	LDGT2	6	8	48	20	120
	Pickup Fracing Engineer	10,000	HDDV	6	2	12	4	24
	Pickup Co. Supervisor	7,000	LDGT2	6	8	48	20	120
	Pickup Miscellaneous Supplies	7,000	LDGT2	6	8	48	20	120
	Pickup Roustabout Crew	12,000	HDDV	6	2	12	6	36
Well Head Compressors	Semi Trucks	60,000	HDDV	6	2	12	6	150
	Haul Trucks	45,000	HDDV	6	2	12	6	36
	Pickup Trucks	7,000	LDGT2	6	2	12	6	36
Central Compressor Station	Semi Trucks	60,000	HDDV	6	2	12	6	150
	Haul Trucks	45,000	HDDV	6	2	12	6	36
	Pickup Trucks	7,000	HDDV	6	2	12	6	36
Natural Gas Production Road Traffic								
Inspection Visits for Compressor Stations	Pickup Truck	7,000	LDGT2	10	52[c]	520	52[c]	520
Well Workover	Workover Rig	120,000	HDDV	3	2	6	2	6
	Haul Truck	60,000	HDDV	3	2	6	2	6
	Pickup Truck	7,000	LDGT2	3	2	6	2	6
Maintenance Visits to Central Compressor Stations	Pickup Truck	7,000	LGDT2	10	30[c]	300[e]	20[c]	200[e]
Visits for Inspection and Repair –Well pad and pipeline	200-hp Pickup	7,000	LGDT2	75[a]	120[b]/2[c]	1.25	120[b]/2[c]	1.25
Road Maintenance	Grader	-	-	-	-	43646[e]	-	43646[e]

Construction Site Destination	Vehicle Type	Av. Vehicle Weight (lb)	Vehicle Class	Round Trip Distance (mi)	# of Round Trips per Well Pad or per Station for Fugitive Dust	Miles Traveled per Well Pad or per Station for Fugitive Dust	# of Round Trips per Well Pad or per Station for Tailpipe	Miles Traveled per Well Pad or per Station for Tailpipe
Road Maintenance	Pickup Truck	7,000	LGDT2	6[a]	-	8,729	-	8729[e]
Oil Production Traffic								
	Workover Rig	120,000	HDDV	3	2	6	2	6
	Haul Truck	60,000	HDDV	3	2	6	2	6
Well Workover	Pickup Truck	7,000	LDGT2	3	2	6	2	6
Road Maintenance	Grader	-	-	-	-	8726[e]	-	-
Road Maintenance	Pickup Truck	7,000	LGDT2	6[a]	-	1745[e]	-	1745[e]
Oil Tanker Road Traffic	Oil Tanker	75,000	HDDV	10	2,424	24240[e]	2,424	24240[e]

[a] Round trip distance miles/day
[b] Number of wells visited per day
[c] Total Number visits per year
[d] Total operating days
[e] Total miles maintained/travelled

Table 18. LSFO RMP EIS Emissions Estimates for On-Road Traffic and Off-Road Construction Equipment.

Source Category	NOx (lb/well pad lb/stn or lb/project)	PM10 (lb/well pad lb/stn or lb/project)	PM2.5 (lb/well pad lb/stn or lb/project)	SO2 (lb/well pad lb/stn or lb/project)	CO (lb/well pad lb/stn or lb/project)	VOC (lb/well pad lb/stn or lb/project)	Fugitive PM10 (lb/well pad lb/stn or lb/project)	Fugitive PM2.5 (lb/well pad lb/stn or lb/project)
Drilling and production roads	146.44	13.10	0.10	16.08	38.90	11.66	30.00	4.40
Drilling and well pad construction (including wellhead compressor installation)	166.92	15.63	0.85	17.67	56.45	19.34	102.00	15.20
Pipeline construction	59.25	5.05	0.05	5.54	21.76	5.15	18.00	2.60
Central compressor station construction	120.89	11.42	0.85	13.06	42.14	14.12	66.00	10.00
Electric line installation	0.25	0.05	0.05	0.04	0.76	0.15	17.60	2.60
Drilling (rig up, drilling, and rig down)	6.34	1.41	1.27	1.20	22.39	3.93	230.40	34.80
Completion	19.78	4.61	4.22	3.88	53.04	11.92	532.40	80.60
Natural Gas Production Traffic: Inspection Visits for Compressor Stations	11.58	1.15	0.92	1.26	133.44	8.60	3276.00	468.00
Well Workover Road Traffic (lb/well)	0.20	0.00	-	0.00	0.60	0.20	31.00	4.00
Well and Pipeline Road Traffic Visits for Inspection and Repair (lb/well-yr)	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.10
Natural Gas & Oil Well Construction and Natural Gas Production: Road Maintenance	18592.77	1658.51	1658.51	2269.54	4015.34	960.19	33389.19	3011.57
Natural Gas and Oil Well Construction and Natural Gas Production: Commuting Maintenance Vehicles Road Traffic	19.44	1.92	1.54	2.12	224.00	14.43	5499.27	785.61
Maintenance Visits to Central Compressor Stations, Long-term Natural Gas Production	0.45	0.04	0.04	0.05	5.13	0.33	189.00	27.00
Oil Well Prodcuton: Workover Road Traffic, Fugitive Dust (lb/well)	-	-	-	-	-	-	31.00	4.00
Oil Well Production : Road Maintenance	3716.85	331.55	331.55	453.70	802.70	191.95	6675.39	602.09
Oil Well Production: Commuting Maintenance Vehicles Road Traffic	3.89	0.38	0.31	0.42	44.78	2.89	1099.35	157.05
Oil Well Production: Tanker Road Traffic	0.72	0.17	0.16	0.14	1.51	0.43	50176.80	7514.40

Uncertainty/Error Analysis

The LSFO RMP EIS did not contain any uncertainty or error analysis associated with the collection/aggregation of survey data or the subsequent emissions calculations. No ranges of activity or equipment data (and subsequent emissions estimates) were presented in the air quality analysis.

CONCLUSIONS

A review of four studies that include oil and gas mobile sources in their scopes has been conducted, including environmental impact statements for specific projects, resource management plans for large areas, and a special study of oil and gas development-related traffic. The results of the literature review of these studies indicate that this sector has been considered to differing extents in past air quality analyses.

The studies differ in the extent to which they cover various mobile source categories. The most extensive studies, the Jonah Infill Drilling Project EIS and the LSFO RMP EIS, considered a wide range of mobile source categories covering nearly all phases of well development from initial pad construction to production. The activity sources for all studies were data obtained from oil and gas producers, generally in the form of estimated activity provided by the production companies in relation to the specific projects considered in the documents. No rigorous uncertainty analysis was conducted for any study, although the data obtained as part of the UDOT study in the Uinta Basin did include a range of truck trips per activity.

Emissions analyses were not conducted consistently among the different studies reviewed. Some studies, such as the NSJBCBM Project EIS, did not contain total emissions inventories and the UDOT study did not consider emissions at all. All studies that estimated emissions used EPA's AP-42 emissions factors for both on-road and off-road equipment, following protocols developed for the specific studies or generalized protocols. It should be noted that EPA no longer supports AP-42 emissions factors for on-road mobile sources, and has used the MOBILE model for a number of years. EPA has now finalized and released the MOVES model to replace MOBILE.

The literature review allows for a comparison of emissions from mobile sources associated with the various phases of well development, relative to the drilling/completion emissions previously considered in the WRAP and other regional oil and gas inventories. The Jonah Infill Drilling and North San Juan CBM Project results for emissions from all mobile sources in the well construction through completion phases were compared against emissions from other drilling and completion activities considered in the Phase III study. The other drilling and completion activities include emissions from operation of the drilling rig itself and venting/flaring emissions from completion. The results of the comparison differ depending on the specific assumptions used in each document, both for the mobile sources and for the other emissions. In the Jonah Infill Drilling EIS the combined emissions from mobile sources associated with well pad construction, drill rig movement, and completion activities and all associated road traffic range from approximately 5% - 16% of the total NOx emissions from drilling and completion flaring, and 6% - 57% of the SOx emissions from drilling and completion flaring. In the North San Juan CBM Project EIS the combined emissions from the mobile sources are approximately 49% of the NOx emissions from drilling and completion flaring, and 78% of the SOx emissions from drilling and completion flaring. In both documents, the mobile source emissions are a negligible fraction of the VOC emissions from drilling and completion activities, and the PM emissions (including fugitive dust) are significantly greater from the mobile sources than from drilling rigs or other completion activities. This comparison indicates that the evaluation of mobile source emissions has the potential to significantly impact the emissions totals for similar activities from the previous inventories, such as the WRAP Phase III inventory.

The findings of the literature review suggest that the scope and proposed approach of the Piceance Basin pilot study would improve the quality, accuracy and comprehensiveness of emissions estimates for oil and gas mobile sources in this region. The geographic scopes of these four studies were limited to either specific development projects (in the case of EIS documents) or to specific regions (in the case of the RMP documents). Only the Utah DOT study covered a wide geographic area including the entirety of the oil and gas development areas of the Uinta Basin. By contrast, the Piceance Basin pilot study will develop oil and gas mobile source activity covering the entirety of the Piceance Basin. The EIS documents – both the Jonah Infill Drilling Project and the North San Juan CBM Project – were limited by nature to specific production types and thus did not cover all of the production types included in the Piceance Basin pilot study. The UDOT study similarly covered only oil production in the Uinta Basin. Only the BLM Little Snake Field Office RMP EIS covered both oil and gas production. The methodologies of all studies essentially relied on data from producers, similar to the survey approach proposed in the Piceance Basin pilot study. However, the oil and gas producers providing data to the EIS analyses in particular only represented the applicants for specific projects, and did not represent all production in the geographic areas of each analysis. In the case of the UDOT study and the Little Snake Field Office RMP, although the analyses relied on data from multiple oil and gas producers, neither document indicated the percentage of well, production or activity ownership represented by survey respondents. This is a key step in the Piceance Basin pilot study to ensure that survey responses are representative of the majority of oil and gas activity occurring in the basin. The emissions factor data for most of the studies came from AP-42 or other sources. AP-42 emissions factors are not the EPA's recommended emissions factor source for both off-road and on-road sources, as they have been superseded by the NONROAD and MOBILE/MOVES models. The Piceance Basin pilot study will use these more recent models to develop emissions rather than relying on the older emissions factor compilation in AP-42. The source categories considered in the four studies reviewed varied, with the UDOT study focusing exclusively on on-road mobile sources and the other studies considering both on-road and off-road sources associated specifically with the well development. In comparison to the four studies considered in the literature review, the proposed scope of work for the Piceance Basin pilot study covers a similar scope of well development and production activities, but includes ancillary activities and includes a request for data on a complete trip by on-road vehicles (including both within the field and outside of the field). None of the studies considered in the literature review provided an uncertainty analysis, or an indication of the degree to which the data gathered were representative of activity in the geographic region. The Piceance Basin pilot study will include this information as the study is structured to assess the complete inventory of mobile sources for the basin and the quality of the data received. Therefore the approach proposed in the Piceance Basin pilot study offers considerable advantages over the past studies considered in the literature review.

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