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Bureau of Land Management

Air Quality Technical Support Document

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Chevron U.S.A., Inc.
Hayhurst Master Development Plan

U.S. Department of the Interior
Bureau of Land Management
Pecos District
Carlsbad Field Office
620 East Greene Street
Carlsbad, NM88220
Phone: (575) 234-5972
FAX: (575) 885-9264

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BLM

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1. STUDY AREA AND BACKGROUND FOR AIR QUALITY ANALYSES

This section describes the existing condition and future trends of air quality resources that may be impacted by implementing the proposed action or an alternative (BLM, NEPA Handbook, 2008). “Human environment” relates to biological, physical, social and economic elements of the environment. In addition to describing the physical conditions of the study area, this section provides a description of the applicable air quality regulations and standards. This proposed development coincides with the Bureau of Land Management (BLM) Carlsbad Field Office (CFO) Resource Management Plan (RMP), revised in April 2013 (USDI, BLM 2013). As such, much of the information referenced in this section is incorporated from the Air Resources Technical Support Document (ARTSD) to the RMP (URS, 2013).

The area of analysis for air resources is the Permian Basin whose airshed covers southeastern New Mexico and the northern panhandle of Texas. The proposed action is to implement the Hayhurst Development Area (HDA), an oil and gas development area located in southeast New Mexico in Eddy County. Air quality in the project area has the potential to be affected by project activities such as emissions from drilling and completion of new wells and the construction and operation of oil and gas facilities and infrastructure. Regional air quality can also be affected by natural events such as windstorms and wildfires. The duration of events is generally short, lasting several hours to several days. The effects of these events may impact human health and environment; however, they are considered part of the natural and physical environment.

1.1. Regional Setting for Air Quality

The planning area is located in a semiarid climate regime typified by dry windy conditions, limited rainfall, hot summers and mild winters. Summertime maximum temperatures are generally in the 90s (all temperatures are in Fahrenheit degrees) with occasional temperatures over 110. Winter minimum temperatures are generally in between 20s and 30s with extremes remaining above zero degrees. Precipitation is mainly in the form of summer thunderstorms associated with the Southwest Monsoon though occasional Pacific storms drop south into New Mexico during the winter. **Table 1-1** shows climate normals 1981-2010 for Carlsbad Monitoring Station (NOAA, 2011).

Table 1-1 Climate Normals for Carlsbad, 1981-2010

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Temperature (°F)	42.6	47.2	54.0	62.4	71.5	79.3	81.2	79.9	73.2	62.9	51.5	42.8
Average Maximum Temperature (°F)	57.5	62.7	70.2	78.5	86.9	94.4	94.6	93.1	87.0	78.1	67.1	57.5
Average Minimum Temperature (°F)	27.6	31.7	37.9	46.2	56.0	64.3	67.7	66.6	59.4	47.7	35.8	28.0
Average Precipitation (inches)	0.47	0.54	0.51	0.64	1.17	1.53	2.01	1.83	2.11	1.16	0.81	0.63

Source: NOAA, 2011

Prevailing winds are from the southeast with speeds varying from 0 miles per hour (mph) to 20 mph, rarely exceeding 31 mph (WeatherSpark, 2016). **Figure 1-1** and **Figure 1-2** show the distribution of magnitude and direction of local winds for 2014 from the Cavern City Airport in Carlsbad, New Mexico (NM) and the Lea County Regional Airport in Hobbs, NM, respectively (NCDC 2014).

1.2. Existing Air Quality

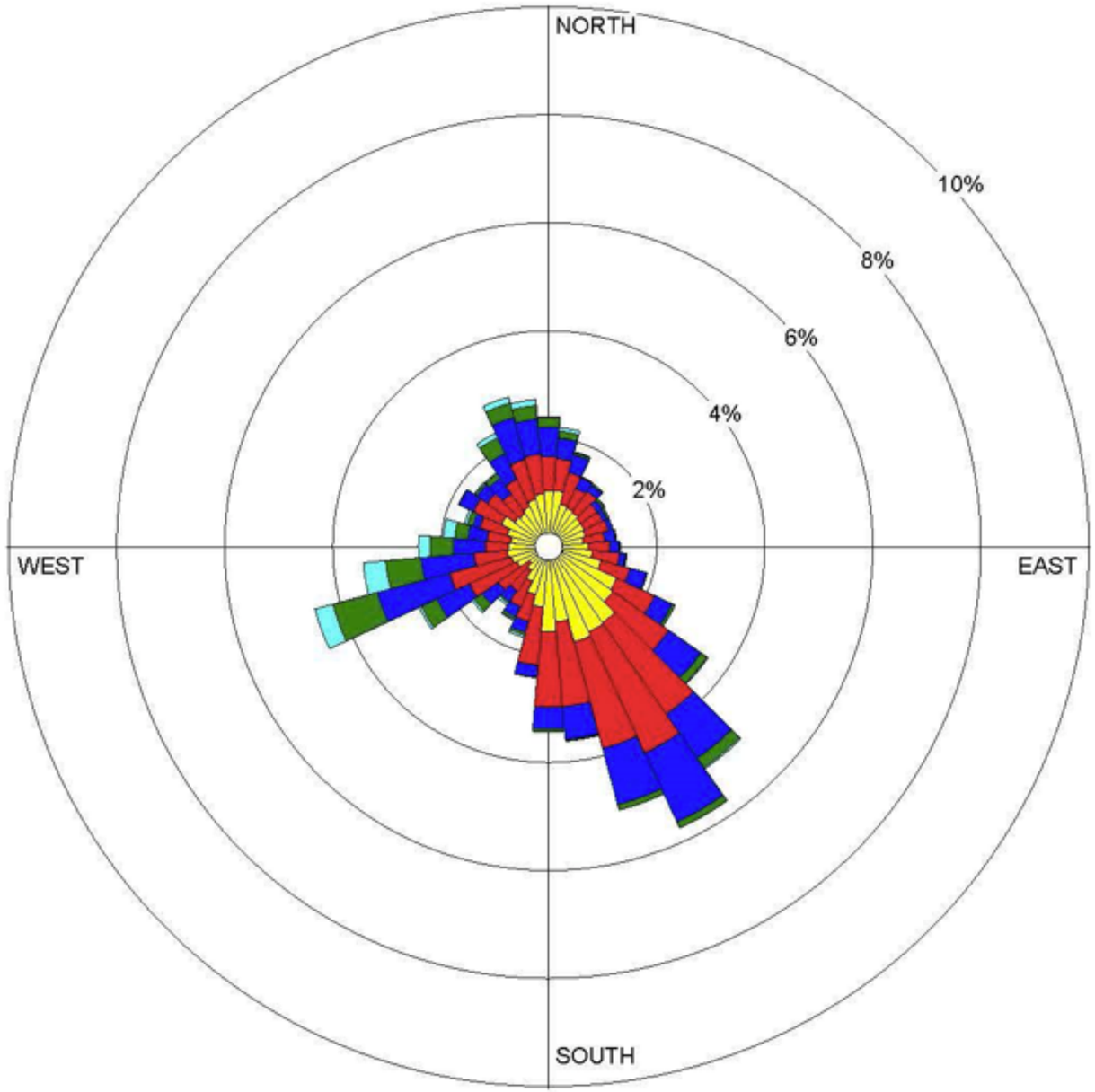
Air quality in a given location is defined by pollutant concentrations in the atmosphere and is generally expressed in units of parts per million (ppm) or micrograms per cubic meter (µg/m3). The existing air quality in the proposed development area is considered to be acceptable for human health and the environment since it is in attainment of the National Ambient Air Quality Standards (NAAQS) and State AAQS (SAAQS) or has insufficient data to establish compliance. The United States Environmental Protection Agency (EPA) Green Book web page (EPA, 2015) reports that the Permian Basin is in attainment for all NAAQS as defined by the Clean Air Act (CAA).

The CFO recently installed monitors in the HDA airshed, including Carlsbad, Carlsbad Caverns National Park, and Hobbs (URS 2013) to monitor ambient concentrations of criteria air pollutants. Monitored design values for ozone (O_3), nitrogen dioxide (NO_2), particulate matter with aerodynamic diameter less than 10 microns and 2.5 microns (PM_{10} and $PM_{2.5}$, respectively), carbon monoxide (CO) and sulfur dioxide (SO_2) are shown in varied units in **Table 1-2**. Design values are the concentrations of air pollution at a specific monitoring site represented in the averaging period that can be compared to the NAAQS. There is no monitoring conducted for lead and CO in southeastern New Mexico; however, concentrations of these pollutants are expected to be low in rural areas and are therefore not monitored. CO is monitored, however, in Texas. The New Mexico Environment Department (NMED) discontinued monitoring for SO_2 in Eddy County due to very low monitored concentrations. Design values for PM_{10} in southeastern New Mexico are not available due to incomplete data collection.

Table 1-2 Design Concentrations of Criteria Pollutants in the HDA Airshed

Pollutant	Averaging Period	Location	Design Value (units vary)					NAAQS
			2008	2011	2012	2013	2014	
O_3	8-hour	Hobbs	0.067 ppm(1)	0.061 ppm	--	--	0.065	0.070 ppm(4)
		Carlsbad	0.067 ppm(1)	0.069 ppm	--	--	--	
NO_2	Annual	Hobbs	--	6 ppb	--	--	--	53 ppb
		Carlsbad	--	3 ppb	--	--	2.8 ppb(2)	
	1-hour	Carlsbad	--	42 ppb	18.4 ppb(3)	18.4 ppb(3)	18.4 ppb(3)	100 ppb(5)
$PM_{2.5}$	Annual	Hobbs	--		7.8 µg/m3(6)	7.8 µg/m3(6)	7.8 µg/m3(6)	12 µg/m3
	24-hour	Hobbs	--	21.9 µg/m3(7)	21.9 µg/m3(7)	21.9 µg/m3(7)	--	35 µg/m3
PM_{10}(8)	24-hour	--	--	--	--	--	--	150 µg/m3
CO	8-hour	El Paso, TX	--	--	1.5 ppm(9)	1.5 ppm(9)	1.5 ppm(9)	9 ppm
	1-hour	El Paso, TX	--	--	2.1 ppm(9)	2.1 ppm(9)	2.1 ppm(9)	35 ppm
SO_2	Annual	El Paso, TX	--	--	0.0006 ppm(9)	0.0006 ppm(9)	0.0006 ppm(9)	0.03 ppm
	24-hour	El Paso, TX	--	--	0.0017 ppm(10)	0.0017 ppm(10)	0.0017 ppm(10)	0.14 ppm
	3-hour	El Paso, TX	--	--	0.0065 ppm(10)	0.0065 ppm(10)	0.0065 ppm(10)	0.5 ppm
	1-hour	El Paso, TX	--	--	4.7 ppb(11)	4.7 ppb(11)	4.7 ppb(11)	75 ppb

Notes:
1 Annual fourth-highest daily maximum 8-hour concentration (URS 2013, Table 4-7)
2 Highest annual value from the most recent year monitored (2014) (1 ppb = 1.88 µg/m3) (NMED 2014).
3 3-year average of 98th percentile of 1-hour max used (2012-2014) (1 ppb = 1.88 µg/m3) (NMED 2014).
4 Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.
5 98th percentile, averaged over 3 years.
6 Average of annual values from three years of data set (2012-2014) (NMED 2014).
7 3-year average of 98th percentile of 24-hour max used (2011-2013) (NMED 2014).
8 No PM_{10} data is available as there are no PM_{10} monitors within the HDA airshed.
9 Highest annual value over three years (2012-2014) (TCEQ 2014).
10 Highest annual value of the 3-hour max over three years (2012-2014) (TCEQ 2014).
11 3-year average of 99th percentile of 1-hour max used (2012-2014) (TCEQ 2014).



LEGEND

WIND SPEED
(m/s)

- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

Calms: 13.73%

Notes:
Windrose Plot = Cavern City Air Terminal
Display = Wind speed direction (blowing from)
Start Date = 1/1/2014 - 00:00
End Date = 12/31/2014 - 23:00
Calm Winds = 13.73%
Avg. Wind Speed = 3.89 m/s
Modeler = Jalbert
Total Count = 8748 hrs.

CHEVRON HAYHURST

FIGURE 1-1
Carlsbad, NM Windrose, 2014

ANALYSIS AREA: Eddy County, New Mexico

Date: 3/14/2016	Prepared By: BW

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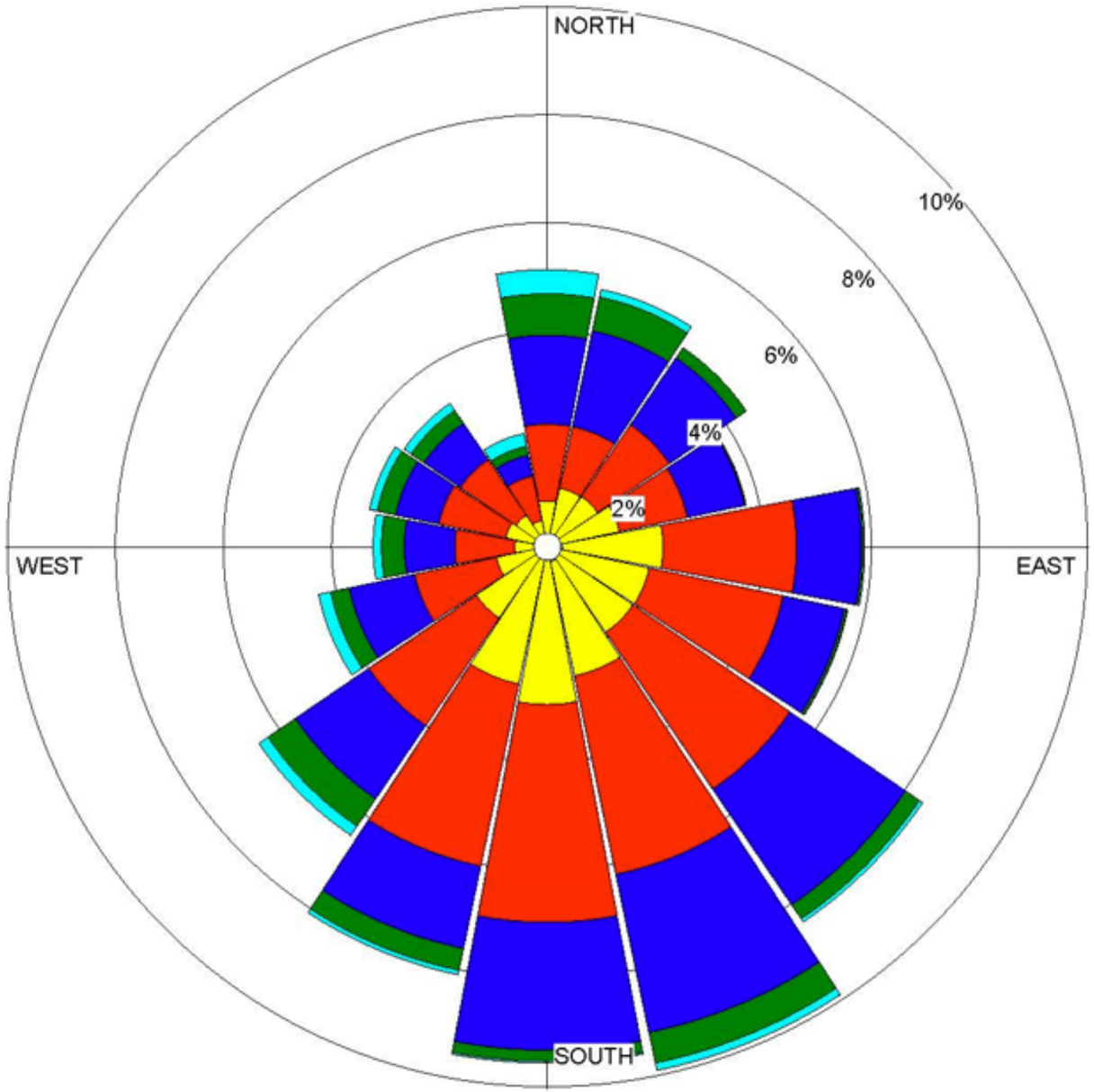

LEGEND

WIND SPEED
(m/s)

- >= 11.1
- 8.8 - 11.1
- 5.7 - 8.8
- 3.6 - 5.7
- 2.1 - 3.6
- 0.5 - 2.1

Calms: 11.66%

Notes:
Windrose Plot = Lea County Regional Airport (Hobbs, NM)
Display = Wind speed direction (blowing from)
Start Date = 1/1/2014 - 02:00
End Date = 12/31/2014 - 23:00
Calm Winds = 11.66%
Avg. Wind Speed = 4.43 m/s
Modeler = Jalbert
Total Count = 8345 hrs.

CHEVRON HAYHURST

FIGURE 1-2
Hobbs, NM Windrose, 2014

ANALYSIS AREA: Eddy County, New Mexico	
Date: 3/14/2016	Prepared By: BW
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The EPA conducts a periodic National Air Toxics Assessment (NATA) to quantify hazardous air pollutant (HAP) impacts by county and identify areas where HAP emissions result in high health risks and further emissions reduction strategies are necessary. A review of the 2011 NATA results shows that cancer, neurological, and respiratory risks in Eddy and Lea Counties are generally increasing compared to statewide and national levels (EPA 2011).

1.3. Standards and Evaluation

The Clean Air Act (CAA) of 1970 (42 USC 7401 et seq.) as amended in 1977 and 1990 is the basic federal statute governing air pollution. Provisions of the CAA of 1970 that potentially are relevant to the Chevron Hayhurst MDP are listed and discussed below:

- NAAQS;
- New Source Review (NSR);
- Prevention of Significant Deterioration (PSD);
- Nonattainment New Source Review (NNSR);
- Conformity Regulations;
- New Source Performance Standards (NSPS); and
- Maximum Achievable Control Technology (MACT) Standards.

National Ambient Air Quality Standards

The Federal CAA amendments of the 1990s require all states to control air pollution emission sources so that NAAQS are met and maintained. In addition to these requirements, the National Park Service (NPS) Organic Act requires the NPS to protect the natural resources of the lands it manages from the adverse effects of air pollution.

The NAAQS establishes maximum acceptable concentrations for NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$, ozone, and lead. Given the extremely low levels of lead emissions from project sources, the lead standards are not addressed in this analysis. These pollutants are known as criteria pollutants. The NAAQS are established by the USEPA and are outlined in 40 CFR 50. These standards represent the maximum allowable atmospheric concentrations that may occur without jeopardizing public health and welfare, and include a reasonable margin of safety to protect the more sensitive individuals in the population. The NAAQS represent maximum acceptable concentrations that generally may not be exceeded more than once per year; the annual standards may never be exceeded. An area that does not meet the NAAQS is designated as a nonattainment area on a pollutant-by-pollutant basis. Applicable federal and state criteria are presented in **Table 1-3**.

Table 1-3 National Ambient Air Quality Standards

Pollutant (units)	Averaging Period	Ambient Air Quality Standards[1]	
		National	New Mexico
NO_2 (varies)	Annual[2]	100 µg/m^3	0.05 ppm
CO (varies)	1-hour[3]	40,000 µg/m^3	13.1 ppm
	8-hour[3]	10,000	8.7 ppm
SO_2 (varies)	3-hour[3]	1,300	N/A
	24-hour[3]	260 µg/m^3	0.10 ppm
	Annual[2]	60	0.02 ppm
PM_{10} (µg/m^3)	24-hour[4]	150	150
	Annual[2]	50	60
$PM_{2.5}$ (µg/m^3)	24-hour[5]	35	N/A
	Annual[6]	15	N/A
Ozone (ppm)	8-hour[8]	0.070	N/A

Table 1-3 National Ambient Air Quality Standards

Pollutant (units)	Averaging Period	Ambient Air Quality Standards[1]	
		National	New Mexico

Notes:
1 Sources: USEPA 2016 and NMED 2016.
2 Never to be exceeded.
3 Not to be exceeded more than once per year.
4 Not to be exceeded more than once per year on average over 3 years.
5 Three-year average of the 98th percentile of the 24-hour concentrations at each population-oriented monitor within an area must not exceed this standard.
6 Three-year average of the weighted annual mean concentrations from single or multiple community-oriented monitors must not exceed this standard.
7 The annual PM_{10} NAAQS of 50 µg/m^3 was revoked by USEPA on September 21, 2006.See Federal Register Volume 71, Number 200, October 17, 2006.
8 Values provided reflect the new standard of 0.070 ppm. Three-year average of the fourth highest daily maximum 8-hour average measured at each monitor within an area over each year must not exceed this standard.

New Source Review

The New Source Review (NSR) Permitting program was established by Congress as part of the 1977 CAA Amendments (EPA, 2016a). NSR permitting protects air quality when new facilities are built or modified and assures new or modified industries operate as clean as possible. It also assures that improvements in pollution control occur concurrently with industrial development. Under NSR permitting, stationary sources of air pollution cannot begin construction without obtaining a permit.

There are three (3) categories of NSR permitting requirements, which a source may have to meet one or more of:

1) Prevention of Significant Deterioration (PSD) permits are required for new major sources or a major source making a major modification in areas that meet the NAAQS;
2) Nonattainment NSR (NNSR) permits which are required for new major sources or major sources making a major modification in areas that do not meet one or more of the NAAQS; and,
3) Minor source permits which are for stationary sources that do no not require PSD or NNSR permits.

Prevention of Significant Deterioration

Prevention of Significant Deterioration (PSD) regulations restrict the degree of ambient air quality deterioration allowed and apply to proposed new or modified major stationary sources located in an attainment area that have the potential to emit criteria pollutants in excess of predetermined threshold values (40 CFR Part 51). In New Mexico, PSD permits are required prior to construction or modification of sources subject to 20.2.74 NMAC. Increments for criteria pollutants are based on the PSD classification of the area. Class I area status is assigned to federally protected wilderness areas and allows the lowest amount of permissible deterioration. Class I areas allow the lowest amount of air quality increment consumption, while Class II designations allow higher increment consumption. There are no designated Class III or heavy industrial use areas.

As defined in 40 CFR 51 and 20.2.74 NMAC, a source is a major stationary source if it:

1) Can be classified in one of the 28 named source categories listed in Section 169 of the CAA and it emits or has the potential to emit 100 tons per year (tpy) or more of any pollutant regulated by the Act; or,
2) Is any other stationary source that emits or has the potential to emit 250 tpy or more of any pollutants regulated by the CAA (USEPA 1990).

Compressor stations, tank batteries, and other upstream oil and gas sources are not listed as one of the 28 named source types in Section 169 of the Act; therefore, 250 tpy is the threshold for major source status.

In Massachusetts v. USEPA, the U.S. Supreme Court (Supreme Court) (April 7, 2007) held that CO2 satisfies the definition of "air pollutant" and that USEPA has authority to regulate emissions of CO2 and other GHGs the CAA. The Supreme Court remanded the case to USEPA to determine whether such emissions contribute to global climate change, and thereby endanger public health or welfare. The ruling, however, did not require the USEPA to create any emission control standards or ambient air quality standards for GHG emissions. On May 13, 2010, USEPA promulgated rule changes to 40 CFR 52.21, known as the "GHG Tailoring Rule", which regulated permitting of GHG as a criteria pollutant under PSD. However, the Supreme Court later vacated most portions of this ruling.

On June 23, 2014, the Supreme Court issued its decision on the Tailoring Rule upholding USEPA authority to regulate greenhouse gas (GHG) emissions for certain facilities, specifically those required to obtain a PSD permit due to the emission of other regulated pollutants. However, the Supreme Court indicated that the USEPA exceeded its statutory authority when it interpreted the CAA to require PSD and Title V permitting for stationary sources based on their GHG emissions alone. As such, only those sources that would otherwise be subject to PSD for criteria air pollutants may be subject to PSD permitting for GHG if they exceed major source threshold.

In addition to more stringent PSD increments, Class I areas are protected by Federal Land Managers (FLMs) by management of air quality related values (AQRVs) such as visibility and acid deposition. Though not a regulatory program under PSD, FLMs review the issuance of a PSD permit for any impacts that exceed guideline thresholds for these parameters. The air quality impacts in the area must meet the NAAQS, which apply nationwide. The locations of Class I and sensitive Class II areas within 300 km of the HDA are shown in **Figure 1-3**, and are summarized in **Table 1-4**.The nearest Class I area is Carlsbad Caverns National Park about 28 km northwest of the HDA. The proximity of this Class I area provides concern that ambient air quality could see both near-field and regional impacts.

Table 1-4 Class I and Sensitive Class II Areas of Concern for Air Quality Impact Analysis

Class I Areas	Sensitive Class II Areas
Carlsbad Caverns NP (NPS)	Bitter Lake National Wildlife Refuge (USFWS)
Guadalupe Mountains NP (NPS)	Grulla National Wildlife Refuge (USFWS)
White Mountain Wilderness Area (USFS)	San Andreas National Wildlife Refuge (USFWS)
Salt Creek Wilderness Area (USFWS)	White Sands National Monument (NPS)
Big Bend NP (NPS)	

Abbreviations:
NP = National Park
NPS = National Park Service
USFS = US Forest Service
USFWS = US Fish and Wildlife Service

Allowable deterioration to air quality can be expressed as the incremental increase to ambient concentrations of criteria pollutants, or PSD increment. Modeled air concentrations of NO_2, SO_2, and PM_{10} predicted at near-field receptors that result from the emissions due to project sources are compared with the convenient threshold of allowable PSD increments. This comparison to PSD Class II increments does not represent a regulatory PSD increment consumption analysis because the focus of this study is the proposed action and alternatives under the National Environmental Policy Act (NEPA), not increment-

affecting sources, which are not evaluated for regulatory purposes under NEPA. The allowable PSD increments for Class II areas are given in **Table 1-5**.

Table 1-5 PSD Increments for Class I and Class II Areas

PSD Class	Pollutant	Allowable Increment (µg/m^3)		
		Annual Arithmetic Mean	24-hour Maximum	3-hour Maximum
Class I	NO_2	2.5	-	-
	SO_2	2	5	25
	PM_{10}	4	8	-
Class II	NO_2	25	-	-
	SO_2	20	91	512
	PM_{10}	17	30	-

Nonattainment New Source Review

Nonattainment New Source Review (NNSR) is required for major stationary sources locating or expanding in nonattainment areas. In New Mexico, NNSR permits are required prior to construction or modification of sources subject to 20.2.79 NMAC.NNSR requires the installation of Lowest Achievable Emission Rate (LAER) controls and emissions offsets for non-attainment pollutants. The areas potentially impacted by the proposed project are currently listed as attainment or unclassifiable for all criteria pollutants; therefore, NNSR does not apply.

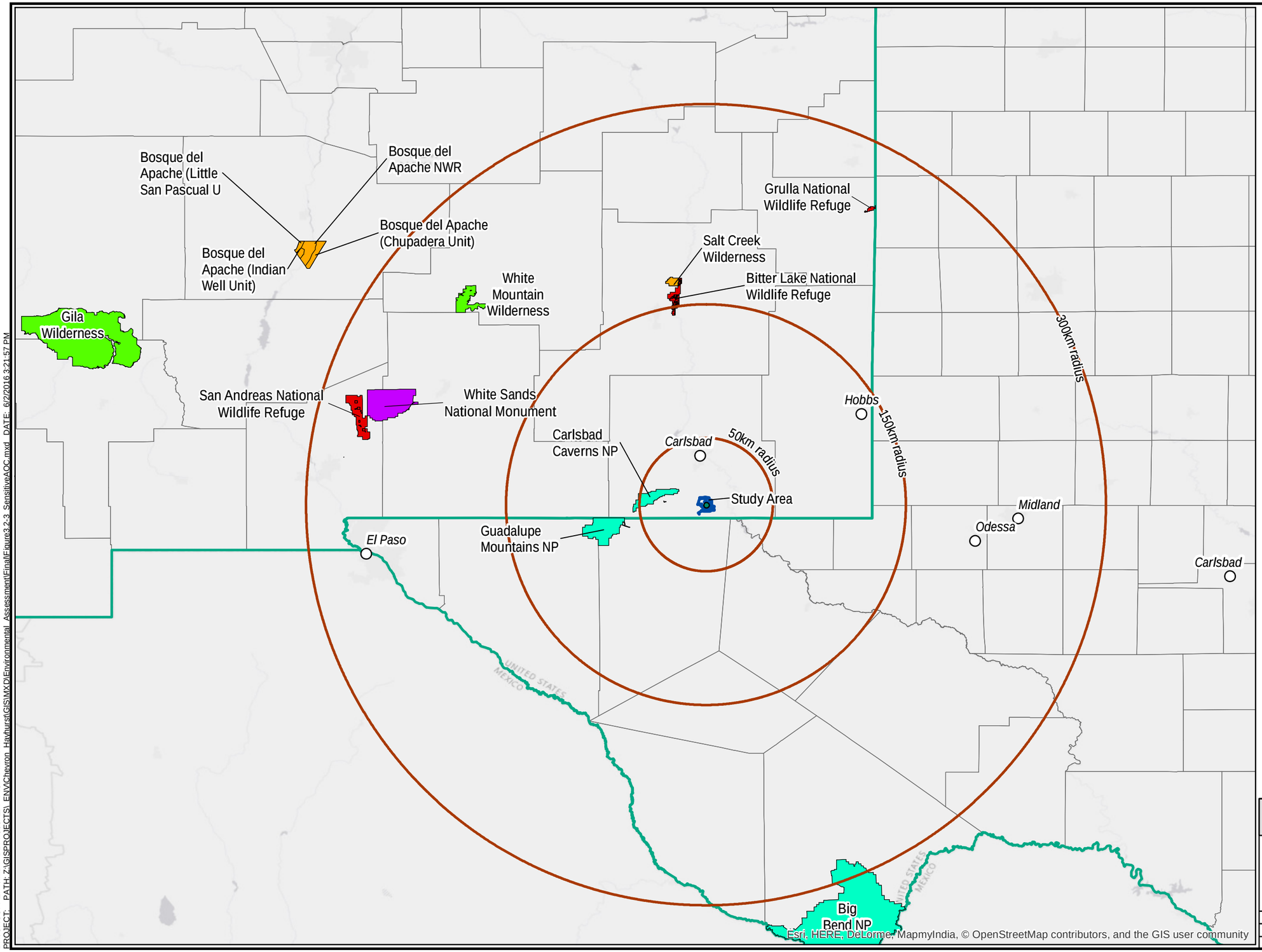
Minor Source Permitting

Minor source permits are for stationary sources that do no not require PSD or NNSR permits. The purpose of minor NSR permits is to prevent the construction of sources that would interfere with attainment or maintenance of a NAAQS or violate the control strategy in nonattainment areas. Also, minor NSR permits often contain permit conditions to limit the sources emissions to avoid PSD or NNSR. In New Mexico, the following minor source permits exist:

1) **NSR Minor Source Construction Permits**, which are required for all sources with the potential emission rate greater than 10 pounds per hour, or 25 tons per year, of criteria pollutants (see 20.2.72 NMAC);
2) **Streamline Permits**, which are for applicable oil and gas compressor stations that meet streamline permit requirements;
3) **General Construction Permits (GCPs)**, which handle the needs of a specific industry (i.e., GCP numbers 1, 4 and 6 relate to the Oil & Gas industry) (see 20.2.72 NMAC);
4) **Notice of Intent (NOI)**, which are not permits, but are for facilities that emit more than 10 tons per year of an criteria pollutant but less than 25 tons per year (see 20.2.73 NMAC); and,
5) **No Permit Required (NPR)**, which are for facilities that emit less than 10 tons per year of any criteria pollutant.

State Implementation for New Mexico

The New Mexico State Implementation Plan (SIP) has been a continuous arrangement between the USEPA and New Mexico since 1970 to allow the state to adopt rules and responsibilities for applying the federal CAA. The requirements that New Mexico must meet under the SIP are found in Title I of the CAA, which ensures that ambient air quality does not exceed levels that are detrimental to human health or the environment.



LEGEND:

- MDP Project Area
- State Boundary
- County Boundary
- City

Clean Air Act Class I

- U.S. Fish and Wildlife Service
- U.S. National Park Service
- U.S. Forest Service

Sensitive Class II Areas

- U.S. Fish and Wildlife Service
- U.S. National Park Service

Notes:
-Impact analysis for some resources utilizes a different Area of Analysis as illustrated on resource-specific figures

Projection:
WGS 1984

NORTH

0 45 90 Miles

CHEVRON HAYHURST MDP EA

FIGURE 1-3
Class I and Sensitive Class II Areas of Concern Map

ANALYSIS AREA: Eddy County, New Mexico
Date: 6/2/2016 | Prepared By: BW

DIV/GROUP: ENV/IMDV DB: webb LD: PIC: PM: TM:
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Conformity for General Federal Actions

According to Section 176I of the CAA (40 CFR 51.853), a federal agency must make a conformity determination in the approval of a project having air emissions that exceed specified thresholds in nonattainment and/or maintenance areas. The proposed project is not located in a nonattainment or maintenance area; therefore, a general conformity analysis is not required.

New Source Performance Standards

The regulation of new sources, through the development of standards applicable to a specific category of sources, was a significant step taken by the CAA. The significant feature of the law is that it applies to all new, modified, or reconstructed sources within a given category, regardless of geographic location or the existing ambient air quality. The standards defined emission limitations that would be applicable to a particular source group. The New Source Performance Standards (NSPS) potentially applicable to the project include the following subparts of 40 CFR Part 60:

- Subpart A – General Provisions;
- Subpart Dc – Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units;
- Subpart IIII – Standards of Performance for Stationary Compression Ignition Internal Combustion Engines;
- Subpart JJJJ – Standards of Performance for Stationary Spark-Ignition Internal Combustion Engines;
- Subpart KKKK – Standards of Performance for Stationary Combustion Turbines;
- Subpart OOOO – Standards of Performance for Crude Oil and Natural Gas Production, Transmission and Distribution; and,
- Subpart OOOOa –Standards of Performance for Crude Oil and Natural Gas Production, Transmission and Distribution, including CH4 as a regulated pollutant.

<u>Subpart A – General Provisions</u>

Certain provisions of Subpart A apply to the owner or operator of any stationary source subject to a NSPS. Provisions of Subpart A potentially would apply depending on the size and type of compressor-drivers to be installed.

<u>Subpart Dc – Small Industrial-Commercial-Institutional Steam Generating Units</u>

Subpart Dc applies to industrial, commercial, or institutional steam generating units that have a maximum design heat input capacity of 29 megawatts (MW) (100 million British thermal units per hour (MMBtu/h)) or less, but greater than or equal to 2.9 MW (10 MMBtu/h). This subpart potentially would be applicable to large heaters at centralized storage or natural gas treating facilities.

<u>Subpart IIII – Compression Ignition Internal Combustion Engines</u>

On July 11, 2006, the USEPA published in the Federal Register the finalized rule for NOx, CO, and non-methane hydrocarbons from certain new stationary compression-ignited internal combustion (IC) engines that commence construction, modification, or reconstruction after the date the particular standard for a specified engine is identified. For the purposes of this Subpart, the date that construction commences is the date that the engine is ordered by the owner or operator. The requirements of this subpart apply to owners and operators of stationary compression-ignition (CI) IC engines that commence construction after July 11, 2005, where IC engines are manufactured after April 1, 2006 and are not fire pump engines, or are manufactured as a certified National Fire Protection Association (NFPA) fire pump engine after July 1, 2006.

Subpart JJJJ – Spark Ignition Internal Combustion Engines

On January 18, 2008, the USEPA published in the Federal Register the finalized rule for NO_X, CO, and non-methane hydrocarbons from certain new stationary spark-ignited IC engines that commence construction, modification, or reconstruction after the date the particular standard for a specified engine is identified. For the purposes of this Subpart, the date that construction commences is the date that the engine is ordered by the owner or operator. The requirements of this Subpart apply to owners and operators of stationary spark-ignition (SI) IC engines that commence construction after June 12, 2006, where IC engines greater than or equal to 500 hp are manufactured on or after July 1, 2007, and where emergency generator engines are manufactured on or after January 1, 2009.

Subpart KKKK – Stationary Combustion Turbines

On February 18, 2005, the USEPA published proposed rules in the Federal Register for NO_X and SO_2 from new stationary combustion turbines that are larger than 1 MW that commence construction, modification, or reconstruction after February 18, 2005. The preamble to the proposed rule states that new stationary combustion turbines subject to the proposed standards are exempt from the requirements of 40 CFR 60, Subpart GG. Combustion turbines that operate in emergency situations are exempt from the new regulations. The USEPA promulgated the new combustion turbine, Subpart KKKK rule on July 6, 2006.The proposed project does not include the use of combustion turbines for natural gas compression; however, the proponent may elect to use turbines in lieu of internal combustion engines.

Subpart OOOO/OOOOa – Crude Oil and Natural Gas Production, Transmission and Distribution

On August 16, 2012, the USEPA published rules in the Federal Register for VOC and SO_2 emissions from oil and gas production facilities that commence construction, modification or reconstruction after August 23, 2011. Affected facilities include single natural gas wells, wet seal centrifugal and reciprocating compressors prior to natural gas transmission and storage, storage vessels, and sweetening units. On June 3, 2016, USEPA promulgated amendments to this rule to expand the scope of affected sources to include hydraulically fractured oil and gas well completions, pneumatic pumps and controllers, fugitive emissions, and equipment leaks from sources constructed, modified, or reconstructed after the proposed rule date. Moreover, these amendments regulate emissions of methane from existing affected sources.

National Emission Standards for Hazardous Air Pollutants

Under the National Emission Standards for Hazardous Air Pollutants (NESHAP), the USEPA promulgated Maximum Achievable Control Technology (MACT) standards pursuant to Section 112 of the 1990 CAA Amendments and these rules are provided in 40 CFR 63. The MACT standards that potentially would be applicable to the proposed project include:

- Subpart A – General Provisions;
- Subpart HH – Oil and Natural Gas Production Facilities;
- Subpart YYYY – Stationary Combustion Turbines;
- Subpart ZZZZ – Stationary Reciprocating Internal Combustion Engines; and,
- Subpart DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters.

Subpart A – General Provisions

The general provisions for all sources affected by a MACT standard are promulgated under Subpart A. Each of the promulgated standards contains a detailed list of Subpart A that is applicable to the affected facility. The critical sections of Subpart A are summarized in Section 63.6, specifically including paragraph 63.6(e), which provides operation and maintenance requirements.

Subpart HH – Oil and Natural Gas Production Facilities

In the January 3, 2007, Federal Register, the USEPA promulgated a rule to amend 40 CFR 63, Subpart HH to include area sources rather than just major sources of HAPs. An affected source under this final rule is each triethylene glycol (TEG) dehydration unit located at an area source oil and natural gas production facility with the potential to emit benzene greater than 1 ton per year (tpy). The proposed project will include the use of TEG dehydrators which may exceed the 1 tpy threshold.

Subpart YYYY – Stationary Combustion Turbines

The USEPA published the final stationary combustion turbine MACT rule in the Federal Register on March 5, 2004. New lean premix and diffusion flame gas- and oil-fired turbines at major HAP facilities are required to limit formaldehyde emissions to 91 parts per billion volume dry at 15 percent oxygen. On April 7, 2004, the USEPA published two proposed rules affecting natural gas-fired lean premix combustion turbines and three other subcategories. On August 18, 2004, USEPA issued a final rule to stay of the effectiveness for two categories of stationary combustion turbines: lean pre-mix gas-fired turbines and diffusion flame gas-fired turbines. The use of stationary combustion turbines at major sources of HAP is not anticipated for this project.

Subpart ZZZZ – Stationary Reciprocating Internal Combustion Engines

On January 18, 2008, the USEPA published in the Federal Register finalized rules to amend 40 CFR 63, Subpart ZZZZ. An affected source under this amended Subpart is any existing, new, or reconstructed stationary reciprocating internal combustion engine with a site-rating of more than 25 brake horsepower, which are located at either a major source or area source of HAPs.

Subpart DDDDD – Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters

On March 21, 2011, the USEPA published in the Federal Register finalized rules to amend 40 CFR 63, Subpart DDDDD. An affected source under this amended Subpart is any industrial, commercial, or institutional boiler or process heater that is located at a major source of HAP. This rule may apply to process heaters and boilers at natural gas treatment facilities.

Carbon Dioxide and Other Greenhouse Gases

Ongoing scientific research has identified the potential impacts of anthropogenic (man-made) GHG emissions and changes in biological carbon sequestration due to land management activities on global climate. Through complex interactions on a regional and global scale, these GHG emissions and net losses of biological carbon sinks cause a net warming effect of the atmosphere, primarily by decreasing the amount of heat energy radiated by the earth back into space. Although GHG levels have varied for millennia, recent industrialization and burning of fossil carbon sources have caused carbon dioxide equivalent (CO_2e) concentrations to increase dramatically, and are likely to contribute to overall global climatic changes. The Intergovernmental Panel on Climate Change (IPCC) recently concluded that warming of the climate system is unequivocal and most of the observed increase in globally average temperatures since the mid-20th century very likely is due to the observed increase in anthropogenic GHG concentrations (IPCC 2014).

Global mean surface temperatures increased nearly 1.8°F from 1890 to 2006. Models indicate that average temperature changes are likely to be greater in the Northern Hemisphere. Northern latitudes (above 24°N) have exhibited temperature increases of nearly 2.1°F since 1900, with nearly a 1.8°F increase since 1970. Without additional meteorological monitoring systems, it is difficult to determine the spatial and temporal variability and change of climatic conditions, but increasing concentrations of GHGs are likely to accelerate the rate of climate change.

In 2014, the IPCC projected that by the year 2100, global average surface temperatures could increase by 0.5 to 8.5°F above 1990 levels. The National Academy of Sciences (2010) has confirmed these projections, but also has indicated that there are uncertainties regarding how climate change may affect different regions. Computer model predictions indicate that increases in temperature would not be equally

distributed, but are likely to be accentuated at higher latitudes. Warming during the winter months is expected to be greater than during the summer, and increases in daily minimum temperatures are more likely than increases in daily maximum temperatures. Although large-scale spatial shifts in precipitation distribution may occur, these changes are more uncertain and difficult to predict. As with any field of scientific study, there are uncertainties associated with the science of climate change; however, this does not imply that scientists do not have confidence in many aspects of climate change science. Some aspects of the science are known with virtual certainty because they are based on well-known physical laws and documented trends.

Several activities contribute to the phenomena of climate change, including emissions of GHGs (especially CO_2 and methane [CH_4]) from fossil fuel development, large wildfires, activities using combustion engines, changes to the natural carbon cycle, and changes to radiative forces and reflectivity (albedo). It is important to note that GHGs will have a sustained climatic impact over different temporal scales. For example, recent emissions of CO_2 may influence climate for 100 years.

It may be difficult to discern whether climate change is already affecting resources globally, let alone those in the vicinity of the proposed project. In most cases, there is little information about potential or projected effects of global climate change on resources. It is important to note that projected changes are likely to occur over several decades to a century. Therefore, many of the projected changes associated with climate change may not be measurably discernible within the reasonably foreseeable future. Existing climate prediction models are global in nature; therefore, they are not at the appropriate scale to estimate potential impacts of climate change on the vicinity of the project.

Mandatory GHG Reporting Rule: 40 CFR 98, Subpart W

On October 30, 2009, the USEPA issued the final mandatory reporting rule for major sources of GHG emissions. The rule requires a wide range of sources and source groups to record and report selected GHG emissions, including CO_2, CH_4, nitrous oxide (N_2O), and some halogenated compounds. On November 20, 2010, the USEPA issued the final rules for the oil and natural gas industry under 40 CFR Part 98, Subpart W. The rule specifically identifies monitoring and reporting requirements for oil and natural gas systems including on-shore natural gas processing facilities and on-shore natural gas transmission compression facilities, which are applicable components of the proposed project. Further, USEPA finalized changes to Subpart W on October 22, 2015 that broaden the scope of the rule to include centralized tank batteries, oil hydraulic fracturing and well completions, and an additional transmission pipeline segment starting with reporting year 2016.

These USEPA rules do not require any controls or establish any standards related to GHG emissions or impacts. Therefore, there is no evident requirement at this time that would affect development of the proposed project under the proposed rule, other than the possibility of monitoring, recordkeeping, and reporting of GHG emissions.

2. EMISSIONS DATA

This section provides a detailed discussion of the development of the maximum annual emissions from the proposed action. Analysis of the project emissions included the quantification of criteria air pollutants, greenhouse gases, and selected hazardous air pollutants (HAP). Of the 187 HAP regulated under Section 112 of the CAA, the following were selected for analysis because they constitute the greatest contribution, while emission factors for the remaining HAP are negligible.

- Benzene,
- Toluene,
- Ethylbenzene,
- Xylenes (m, p, and o- isomers),
- Formaldehyde, and
- n-Hexane.

The project activities quantified include drilling, completion, compression, and production-related activities. Emissions for each activity were developed on a per unit basis based on approved emission factors, mass balance, or process simulation where appropriate. Supporting information such as operation schedules, equipment specifications, and physical and chemical properties were provided by the proponent where available. Where project-specific information was not available, the analysis used published references or assumptions based on professional experience. A detailed discussion of these parameters appears in the following sections.

2.1. Drilling and Completion Emissions

Drilling emissions include an estimated installation of up to 44 wells each year. Drilling operations consist of three phases. The first phase consists of operating the diesel-fired drill rig and associated equipment to bore to the target production zone. The second phase consists of installation of the well casing and injection of a fracturing liquid to enhance production. Finally, the well is screened in the producing zone and the well is completed by flowing back fracturing liquids. The operation of diesel-fired engines generates criteria pollutants, GHG, and HAP from combustion. In addition, this phase includes the construction of roads and well pads which is a source of fine and respirable particulate matter. The following sections describe the quantification of emissions from sources during this phase.

Engine Emissions

High-powered diesel-fired engines would be used to provide motive force for drilling and completion operations. The rig fleet is generally leased, so the exact number and size of engines cannot be determined with certainty. However, the proponent has provided data on the maximum anticipated engine size, number, and load-level for each phase. The number, type, rating, and operational load for engines used during each phase are summarized in **Table 2-1**.

Table 2-1 Summary of Engine Operating Parameters

Operation	Engine Size (hp)	Number of Engines	Operational Load (%)	Duration (hr/engine-well)
Drilling	2,760	1	100	200[1]
Completion	750	1	100	42[1]
Hydraulic Fracturing	2,250	16	43.6	60
	2,250	2	58.8	13
	850	1	100	60
	600	1	100	60

Notes:
1 Drilling and completion rig duration based on historic fuel use for drill rig fleet in similar operations, brake-specific fuel consumption, and fuel heating value

The currently available fleet is a mixture of Tier 2 and Tier 4 compliant engines as specified in 40 CFR §89.112 for NO_X, CO, PM_{10} ($PM_{2.5}$) and VOC, as nonmethane hydrocarbon (NMHC). The Tier 2 standards combine the emissions of NO_X and NMHC. For Tier 2, NO_X and VOC are speciated, as 95% and 5% respectively, based on the California Air Resources Board (CARB) *Emission Factors for Compression Ignition Diesel Engines – Percent Hydrocarbon in Relation to NMHC + NO_X* (CARB, 2004). Tier 4 standards provide separate standards for NO_X and VOC.

The emission factor for SO_2 was derived using Equation 3-1 assuming 15 parts per million by weight (ppmw) of sulfur as compliant with fuel standards in 40 CFR §80.510.

Equation 2-1 Calculation of SO_2 Emission Factor Based on Fuel Sulfur

$$EF_{SO2} = \frac{15\ lb\ S}{10^6\ lb\ fuel}\ x\ \frac{6.8\ lb\ fuel}{gal}\ x\ \frac{gal}{137{,}000\ Btu}\ x\ \frac{7{,}000\ Btu}{hp-hr}\ x\ \frac{64.03\ lb\ SO_2}{32.06\ lb\ S}\ x\ \frac{453.6\ g}{lb} = 4.7x10^{-3}\ {}^{g}/_{hp-hr}$$

HAP emission factors are a fraction of the VOC based on speciation from the USEPA Nonroad Mobile Inventory Model (NMIM) database (EPA, 2015). GHG emission factors are taken from 40 CFR §98, Table C-1 and C-2 (for distillate fuel oil no. 2). Carbon dioxide equivalents (CO_2e) are calculated using Equation A-1 from 40 CFR §98, Subpart W, which are sum of the products of the mass of each GHG and its global warming potential (GWP) as identified in 40 CFR §98, **Table A-1**.

Emissions are calculated as the product of emission factors, engine rating, operational load, and duration. Detailed emissions calculation tables are provided in **Appendix A, Table A-1** through **Table A-3**. A summary of engine emissions per well for both Tier 2 and Tier 4 rigs is provided **Table A-4**.

Construction Emissions

During the drilling and completion phase, the proponent will construct well pads, facility sites and access roads to them. The total construction per year is provided in **Table 2-2**.The emission estimates are based on emission factors for total suspended particulates from construction activities as described in Section 13.2.3 of AP-42, *Heavy Construction Operations* (USEPA, 1995). Particle size distribution for fine particulate (PM_{10}) and respirable particulate ($PM_{2.5}$) were developed from AP-42, Section 13.2.2 *Unpaved Roads, Background Documentation* (USEPA, 1998b). A control efficiency of 50% was assumed for routine watering operations to suppress dust and mitigate particulate entrainment. No efficiency from naturally occurring precipitation is assumed. Emissions calculations are calculated as shown in **Equation 2-2** with detailed calculations shown in **Appendix A, Table A-5**. Construction is assumed to require five 12-hour days per acre. Monthly emissions are converted to daily and hourly emissions based on a 30-day month.

Table 2-2 Summary of Construction Activities per Year

Facility Type	Size (acre/site)	Number (per year)	Total Construction (acre/year)
Well Pad	3.90	11	42.9
Facility Site	8.03	7	56.2
Road and Right of Way (per mile)	12.36	4	49.4

Equation 2-2 Calculation of Particulate Matter Emissions from Construction Activities

$$E(\frac{tons}{year}) = EF(\frac{1.2\ ton}{acre-month})\ x\ \frac{acres}{year}\ x\ \frac{hours}{pad}\ x\ \frac{pads}{year}\ x\ \frac{ton}{2{,}000\ lb}\ x\ \frac{1-control\%}{100}\ x\ \frac{1}{730}$$

Drilling and Completions Emissions Summary

Emissions from each activity are quantified on a per unit basis and multiplied by the maximum anticipated annual activity during the project. Maximum annual drilling and completion emissions are summarized in **Table 2-3**.

Table 2-3 Emissions Summary for Drilling and Completion

	Drilling and Completion, Emissions per year																	
	Development Area Impact		Criteria Pollutants						Hazardous Air Pollutants						Greenhouse Gases			
			NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	Formaldehyde	n-Hexane	CO_2	CH_4	N_2O	CO_2e
Activity	Quantity[1]	Units	(tons)															
Drill Rig (Tier 2)	11	wells/yr	30.52	17.40	3.16E-02	1.00	1.00	1.61	8.69E-02	6.07E-02	1.52E-02	6.10E-02	0.47	8.69E-03	3,465	0.14	2.81E-02	3,477
Drill Rig (Tier 4)	33	wells/yr	52.21	52.21	9.48E-02	0.60	0.60	2.81	0.15	0.11	2.65E-02	0.11	0.82	1.52E-02	10,396	0.42	8.43E-02	10,431
Completions Rig (Tier 2)	11	wells/yr	1.74	0.99	1.80E-03	5.73E-02	5.73E-02	9.17E-02	4.96E-03	3.47E-03	8.65E-04	3.48E-03	2.68E-02	4.96E-04	198	8.02E-03	1.60E-03	198
Completions Rig (Tier 4)	33	wells/yr	0.57	2.98	5.41E-03	2.52E-02	2.52E-02	0.16	8.68E-03	6.06E-03	1.51E-03	6.10E-03	4.68E-02	8.68E-04	593	2.41E-02	4.81E-03	595
Hydraulic Fracturing (Tier 2)	11	wells/yr	65.64	37.42	6.80E-02	2.16	2.16	3.45	0.19	0.13	3.26E-02	0.13	1.01	1.87E-02	7,452	0.30	5.95E-02	7,477
Hydraulic Fracturing (Tier 4)	33	wells/yr	112.27	112.27	0.20	1.30	1.30	6.05	0.33	0.23	5.71E-02	0.23	1.77	3.27E-02	22,356	0.89	0.18	22,431
Construction PM	N/A	N/A	-	-	-	11.86	3.13	-	-	-	-	-	-	-	-	-	-	-
Total			**262.95**	**223.28**	**0.41**	**17.00**	**8.27**	**14.17**	**0.77**	**0.54**	**0.13**	**0.54**	**4.14**	**0.08**	**44,460**	**1.78**	**0.36**	**44,611**

Notes:

1 Based on plan of development during worst case drilling year (2019)

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2.2. Production Related Emissions

Pollutants are emitted during the operation of production wells and tank batteries. VOC emissions are primarily generated through volatilization of light organic liquids in storage tanks and gas treaters. Additionally, products of combustion are emitted from heaters and boilers used during separation and treatment of produced hydrocarbons. Fugitive emissions result from leaks in flanges, valves, and connectors. Pneumatic devices and pumps will be air-operated or controlled so no regulated pollutants will be emitted. The following sections provide specific information on methodologies and factors used to determine emissions from these sources.

Tank Battery Emissions

The proposed action includes 29 tank batteries which will generate emissions of VOC and HAP from separation and storage of oil/condensate and produced water. The proposed action indicates that liquids will be transported from storage to the customer or disposal via pipeline; therefore, there will be no emissions from the loading of oil or water into transportation vessels. There will be a total 33 oil/condensate tanks and 100 water tanks. Details on emission calculations are provided in the following sections.

Gas-fired Separator Heater Emissions

At each of the 29 tank battery sites, the proponent proposes to install a heater treater which a two or three phase separator equipped with a small (4 MMBtu/hr) gas-fired burner to heat the inlet fluids to boil off any entrained produced gas and aid in the separation of emulsions in the fluid. These heaters operate continuously. Additionally, each heater has a companion heater (4 MMBtu/hr) that will operate during the winter (assume 4 months out of 12 per year) to provide the additional heat duty required to prevent freezing and overcome the larger temperature gradient. Therefore, the calculations assume a total of 11,677 hours of operation per year. Note that the heater treaters are designed to handle surges in liquid flow, and that the actual annual usage is estimated to be 37.6%[1] of design capacity based on the anticipated production schedule. Emission factors are taken from AP-42 Section 1.4, *Natural Gas Combustion* (EPA, 1998a) for small boilers.CO_2e are calculated using Equation A-1 from 40 CFR §98, Subpart W, which are sum of the products of the mass of each GHG and its GWP as identified in 40 CFR §98, Table A-1. Detailed emissions calculation tables are provided in **Appendix A, Table A-6**.

Flashing Emissions

After the separator removes entrained gas, the remaining hydrocarbon liquids and produced water are delivered into tanks. Light hydrocarbons that were in liquid phase under pressure volatilize when returned to ambient pressure resulting in emissions of VOC and HAP. Calculating the emission rate is complex and depends on numerous process variables. These emissions, referred to as flashing, are calculated based on gas-to-oil ratios (GOR) and gas-to-water (GWR) ratios of pressurized samples that were flashed and analyzed by gas chromatography. These analyses are provided in **Appendix B**. Emission factors (in ton per year per barrel per day) are calculated as the product of the GOR/GWR, molar composition of the gas, and molecular weight of each pollutant as shown in **Equation 2-3**.

Equation 2-3 Calculation of Speciated Emissions from Tank Flashing

$$EF\left(\frac{tpy}{bpd}\right) = GOR\left(\frac{scf}{bbl}\right) x \frac{1}{379\frac{scf}{lbmol}}\ x\ MW\ \left(\frac{lb}{lb-mol}\right) x\ WT\% x\ \frac{1\ day}{24\ hours}\ x\ 8{,}760\frac{hours}{year}\ x\ \frac{1\ ton}{2{,}000\ lb}$$

Total emissions are to product of the emission factor and production, estimated at 23,000 barrels per day (BPD) of oil/condensate and 85,000 BPD of produced water. The production volumes are intended to reflect the maximum foreseeable emissions resulting from the proposed action and should not be interpreted as a production forecast. There are numerous uncertainties that could reasonably result in

[1] Email from Chevron to Arcadis on September 8, 2016

lower production and associated emissions in the time horizon considered in this environmental assessment.

The proponent will employ vapor recovery units (VRU) which typically control 100% of the vapor emissions; however, a reduction efficiency of 99.5% to account for periods of startup, shutdown or malfunction. CO_2e are calculated using Equation A-1 from 40 CFR §98, Subpart W, which are sum of the products of the mass of each GHG and its GWP as identified in 40 CFR §98, Table A-1. Detailed emission calculations are shown in **Appendix A, Table A-7**.

Working and Breathing Losses

VOC and HAP are also generated from evaporation of material standing in tanks due to changes in material tank temperature (breathing) and the generation/expulsion of vapors in the head space from emptying and filling of the tank (working). Emissions of VOC were calculated using the methodologies prescribed in AP-42, Section 7.1 *Organic Liquid Storage Tanks* (EPA, 2006).Tank parameters and ambient data (volume, throughput, solar insulation factor) were based on meteorological data for the project area and design parameters provided by the proponent. The proponent will employ vapor recovery units (VRU) which typically control 100% of the vapor emissions; however, a reduction efficiency of 99.5% to account for periods of startup, shutdown or malfunction. Speciation of the vapors were based on the flash gas analysis composition provided in **Appendix B**.CO_2e are calculated using Equation A-1 from 40 CFR §98, Subpart W, which are sum of the products of the mass of each GHG and its GWP as identified in 40 CFR §98, Table A-1. Mass emissions are in units of metric tons per year. Emissions from the tank battery oil and water working and breathing are shown in **Appendix A, Table A-8** and **Table A-9**, respectively**.**

Fugitive Emissions

Emissions of VOC and HAP also result from gas and light oil (condensate) leaking from valves, flanges, connectors, open-ended lines and other connections. The total number of components is based on the total number of facilities provided by the proponent and facility component counts from 40 CFR §98, Table W-1C. Emission factors are based on 40 CFR §98, Table W-1A.CO_2e are calculated using Equation A-1 from 40 CFR §98, Subpart W, which are sum of the products of the mass of each GHG and its GWP as identified in 40 CFR §98, Table A-1. Emissions from fugitive VOCs are shown in **Appendix A, Table A-10**.

Production Emissions Summary

Emissions from each activity are quantified on a per unit basis and multiplied by the maximum anticipated annual activity during the project. Maximum annual production emissions are summarized in **Table 2-4**.

Table 2-4 Emissions Summary for Tank Battery

Activity	Development Area Impact		Tank Battery Emissions - Emissions per year															
			Overall Emissions						Hazardous Air Pollutants						Greenhouse Gases			
			NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylenes	Formaldehyde	n-Hexane	CO_2	CH_4	N_2O	CO_2e
	Quantity[1]	Units	(tons)															
Separator Heaters (Heater Treaters)	29	count	102.15	85.81	6.74E-04	6.06	6.06	4.39	1.68E-03	2.71E-03	-	-	5.98E-02	1.44	66,088	3.36	0.67	66,372
Tank Battery - Oil Flash [2]	23,000	BPD	-	-	-	-	-	156.38	0.12	0.18	1.72E-02	0.10	-	3.17	5.56E-02	4.79	-	120
Tank Battery - Water Flash [2]	85,000	BPD	-	-	-	-	-	0.21	6.42E-03	6.25E-03	2.44E-04	3.32E-03	-	0.00	6.56E-03	0.33	-	8
Tank Battery - Oil Working/Breathing Losses	33	count	-	-	-	-	-	28.09	2.58E-02	2.61E-02	1.20E-03	0.66	-	0.74	2.70E-03	0.13	-	3
Tank Battery - Water Working/Breathing Losses	100	count	-	-	-	-	-	4.34	3.99E-03	4.03E-03	1.85E-04	1.21E-03	-	0.11	4.17E-04	1.95E-02	-	0
Fugitive Emissions	Not applicable [3]		-	-	-	-	-	15.43	1.38E-02	1.40E-02	6.44E-04	4.19E-03	-	0.40	0.14	6.76	-	169
Total			**102.15**	**85.81**	**6.74E-04**	**6.06**	**6.06**	**193.42**	**0.16**	**0.22**	**1.89E-02**	**0.76**	**0.06**	**5.46**	**66,088**	**8.62**	**0.67**	**66,504**

Notes:
1 Based on plan of development.
2 The production volumes listed are intended to reflect the maximum foreseeable emissions resulting from the proposed action and should not be interpreted as a production forecast. There are numerous uncertainties that could reasonably result in lower production and associated emissions in the time horizon considered in this environmental assessment.
3 Fugitives are based on total component count for all wells, and facilities proposed under the plan of development

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2.3. Transmission Emissions

The proponent proposes to install a total of 98 miles of pipeline along with compressor stations to treat produced gas and transport it to customers. Emissions of pollutants occur from the combustion of natural gas in compressors and hydrocarbons stripped from produced gas during dehydration. In addition, emissions of VOC, HAP, and GHG will leak from connections and flanges in the pipeline during transport. The following sections provide detailed of emission calculation methodologies.

Glycol Dehydrators

The proposed action calls for the operation of 11 triethylene glycol (TEG) dehydrators to remove excess water from produced gas prior to compression and sales. A TEG dehydrator is a chemical stripping system where the wet produced gas runs through lean TEG in a contact tower. Water has a differential affinity for glycol than the gas stream, so the TEG strips the water from the gas. Hydrocarbons have some affinity for TEG as well, so the glycol removes a small amount of them as well. The system is a closed-loop, and the rich glycol solution is regenerated to lean glycol by first volatilizing entrained hydrocarbon and water by lowering the pressure of the glycol solution in a flash tank. The rich glycol is then heated in a still to evolve the remaining water and hydrocarbon before returning to the contact tower. This process generates emissions of VOC and HAP, particularly aromatics, which have a higher solubility in water than alkanes or alkenes.

Regenerator Still and Flash Tank Emissions

The regenerator still overhead gas stream contains water vapor and hydrocarbons after the water is separated from the glycol in the reboiler. The proposed design includes a flash tank (as discussed) and a condenser to remove BTEX compounds prior to routing to the reboiler firebox for destruction. The net control efficiency of 95% for the regenerator still vent was based on the condenser reduction of 80% and firebox combustion controls of 75%. The Gas Research Institute (GRI) simulation, GLYCalc v4.0 was used to determine VOC, GHG and HAP emissions for the regenerator still vent based on the proposed design. A summary of the component-specific emissions from the GRI-GLYCalc model is provided in **Appendix B**. Detailed emissions from the regenerator still vent are shown in **Appendix A, Table A-11.**

Reboiler Emissions

The reboiler uses a small (1 MMBtu/hr) gas-fired burner to heat the rich glycol and remove entrained water and hydrocarbons. This heaters operate continuously. Emission factors are taken from AP-42 Section 1.4, Natural Gas Combustion (USEPA, 1998a) for small boilers.CO2e are calculated using **Equation A-1** from 40 CFR §98, Subpart W, which are sum of the products of the masse of each GHG and its global warming potential (GWP) as identified in 40 CFR §98, **Table A-1**.Detailed emissions calculation tables are provided in **Appendix A, Table A-11**.

Compressor Engine Emissions

The proponent is proposing to install and operate 9 compressors to transport produced gas from field production including two small compressors sized at 1,380 bhp and seven large compressors sized at 5,000 bhp. Specifications for these compressors including emission factors for NOX, CO, VOC, and formaldehyde are provided in **Appendix B**. VOC was assumed to equal NMHC. Control efficiency of CO, VOC, and formaldehyde are based on catalyst specifications provided in **Appendix B**. The SO_2 emission factor was calculated based on the brake specific fuel consumption factor and the Federal Energy Regulatory Commission (FERC) standard of 2 grains per 100 standard cubic feet (gr/100 scf) as shown in Equation 3-3.PM and HAP emission factors were based on AP-42, Section 3.2, Natural Gas-fired Reciprocating Engines, Table 3.2-2 (EPA, 2000). GHG emission factors are taken from 40 CFR §98, Table C-1 and C-2 (for fuel gas). CO^2e are calculated using Equation A-1 from 40 CFR §98, Subpart W, which are sum of the products of the masse of each GHG and its GWP as identified in 40 CFR §98, **Table A-1**. Detailed emissions calculation tables are provided in **Appendix A, Table A-12**.

Pipeline Fugitive Emissions

Fugitive emissions were estimated for both protected pipelines and composite pipelines. Protected pipelines will extend for an estimated 78 miles and composite pipelines will extend an estimated 20 miles. Emission factors are based on 40 CFR Part 98, Subpart W, Table W-1A. The total number of components is based on the total number of facilities provided by the proponent and facility component counts from 40 CFR §98, Table W-1C.Emission factors are based on 40 CFR §98, Table W-1A. CO_2e are calculated using Equation A-1 from 40 CFR §98, Subpart W, which are sum of the products of the mass of each GHG and its GWP as identified in 40 CFR §98, Table A-1.Emissions from pipeline fugitive VOCs are shown in **Appendix A, Table A-13**.

Transmission Emissions Summary

Emissions from each activity are quantified on a per unit basis and multiplied by the maximum anticipated annual activity during the project. Maximum annual transmission emissions are summarized in **Table 2-5**.

Emissions Total

The maximum annual emissions based on equipment capacity is summarized in **Table 2-6**. This represents a worst-case scenario if all equipment was run at design capacity. However, production and transmission emissions will vary annually based on the level of production of liquids and gas in the field. Section 3.3 provides a discussion of annual projected emissions from the project based on forecasted production levels.

Table 2-5 Emissions Summary for Production

Activity	Production Emissions - Emissions per year																	
	Development Area Impact		Overall Emissions						Hazardous Air Pollutants						Greenhouse Gases			
			NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	Formaldehyde	n-Hexane	CO_2	CH_4	N_2O	CO_2e
	Quantity[1]	Units	(tons)															
Dehydrator Heaters	11	count	4.72	3.97	3.11E-05	0.28	0.28	73.03	3.43	7.30	1.01	8.67	0.00	1.51	6,267	16.95	-	6,691
Fugitive VOC - Protected Pipelines	78	miles	-	-	-	-	-	2.01	2.34E-03	4.33E-03	4.51E-04	3.16E-03	-	0.05	1.40E-02	5.30	-	132
Fugitive VOC - Composite Pipelines	20	miles	-	-	-	-	-	2.76	3.22E-03	5.95E-03	6.19E-04	4.34E-03	-	0.06	1.92E-02	7.27	-	182
Compressors - Small HP	2	count	13.33	4.56	0.22	6.09E-03	6.09E-03	12.00	3.48E-02	3.22E-02	3.14E-03	1.45E-02	1.60	0.09	10,279	0.52	0.10	10,323
Compressors - Large HP	7	count	101.39	61.23	5.81E-02	7.73E-02	7.73E-02	287.83	0.44	0.41	3.98E-02	0.18	10.17	1.11	130,349	6.63	1.33	130,910
Total			**119.44**	**69.76**	**0.28**	**0.36**	**0.36**	**377.63**	**3.91**	**7.75**	**1.05**	**8.88**	**11.78**	**2.82**	**146,896**	**36.67**	**1.43**	**148,238**

Notes:

1 Based on plan of development at maximum production (2025)

Table 2-6 Overall Annual Emissions for Hayhurst Development Area

Activity	Hayhurst Development Area Overall Annual Emissions																
	Overall Emissions						Hazardous Air Pollutants							Greenhouse Gases			
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylenes	Formaldehyde	n-Hexane	All HAPs	CO_2	CH_4	N_2O	CO_2e
	(tons)																
Drilling Emissions	262.95	223.28	0.41	17.00	8.27	14.17	0.77	0.54	0.13	0.54	4.14	7.67E-02	6.19	44,459.62	1.78	0.36	44,611
Production Emissions	102.15	85.81	6.74E-04	6.06	6.06	193.42	0.16	0.22	1.89E-02	0.76	5.98E-02	5.46	6.68	66,087.77	8.62	0.67	66,504
Transmission Emissions	119.44	69.76	0.28	0.36	0.36	377.63	3.91	7.75	1.05	8.88	11.78	2.82	36.19	130,349.44	6.63	1.33	130,910
Total	**484.54**	**378.84**	**0.69**	**23.43**	**14.70**	**585.21**	**4.84**	**8.50**	**1.21**	**10.18**	**15.97**	**8.36**	**49.06**	**240,896.83**	**17.04**	**2.35**	**242,024**

Notes:
Represents worst case emissions from highest drilling year (2019) and worst case production year (2025).

3. AIR QUALITY AND AIR QUALITY RELATED VALUES IMPACT ANALYSIS

A modeling analysis was conducted to assess potential impacts to air quality near the project area as well as impacts to Air Quality Related Values (AQRV) in nearby Class I areas. The most recent version of the CALPUFF modeling system (Version 5.8.4) was selected as USEPA's recommended modeling system for evaluating AQRV and long-range transport of air pollutants. CALPUFF is a Langrangian puff model with capability to simulate regional-scale, long-range as well as local-scale dispersion (Scire, 2000).

The CALPUFF modeling system has several features that make it best suited to meet the objectives of the analysis.

- The ability to calculate dispersion from time-varying point, volume and area source emissions;
- Valid model domains at distances from 10 meters to hundreds of kilometers from the source;
- Impact prediction for both inert pollutants and chemically reactive pollutants;
- Impact prediction for pollutant removal (such as scavenging and deposition) and atmospheric chemical conversion; and
- Applications in in flat and complex terrain.

The CALPUFF modeling system has three main components:

- Modeling - CALPUFF Version 5.8.4, Level 130731 is the transport and dispersion model that carries out the calculations of dispersion. The settings and domain for this model are discussed in **Sections 3.1** through **3.3**.
- Meteorology - In lieu of CALMET, the three-dimensional meteorological database required for modeling was developed from Weather Research and Forecasting (WRF) meteorological data sets using the Mesoscale Modeling Interface (MMIF). This is discussed further in **Section 3.4**.
- Post-processing - CALPOST Version 5.6394, Level 070622 is the post-processing algorithm that analyzes and reduces the data produced by CALPUFF to determine and depict the predicted concentrations and impacts, both spatially and temporally. The results of the modeling are provided in **Section 3.5**.

The modeling procedure followed the recommendations of the Interagency Workgroup on Air Quality Modeling (IWAQM) and FLAG documents for the assessments of impacts (EPA, 1998c; USFS et al, 2010).

3.1. Model Options and Computational Domain

The IWAQM default settings were used as they were consistent with the current version of CALPUFF. Thus, the default dry and wet deposition algorithms were used. In addition, the following CALPUFF options were selected:

- Pasquill-Gifford (P-G) dispersion coefficient;
- Transitional plume rise;
- Stack tip downwash;
- Transition of horizontal dispersion to time-dependent (Heffter) growth rates;
- Chemical transformation based on MESOPUFF II scheme; and
- Wet and dry deposition modeling

The modeling domain for this study incorporated the Hayhurst project along with the Class I and sensitive Class II areas of interest identified in **Table 1-4**.The domain included primarily southeastern New Mexico, areas in the west Texas and the panhandle area (**Figure 3-1**).The spatial extent of the domain was 188 km (east-west) by 296 km (north-south).The design allowed for 47 by 74 grid cells and 4-km grid element size. The size of the domain required the use of a Lambert Conformal Conic (LCC) grid system as follows:

- Central reference LCC point of 97.º W, 40.º N
- Standard latitude parallels at 33º N and 45º N; and
- Grid origin (southwest corner) offset from central reference point -812 km, -920 km

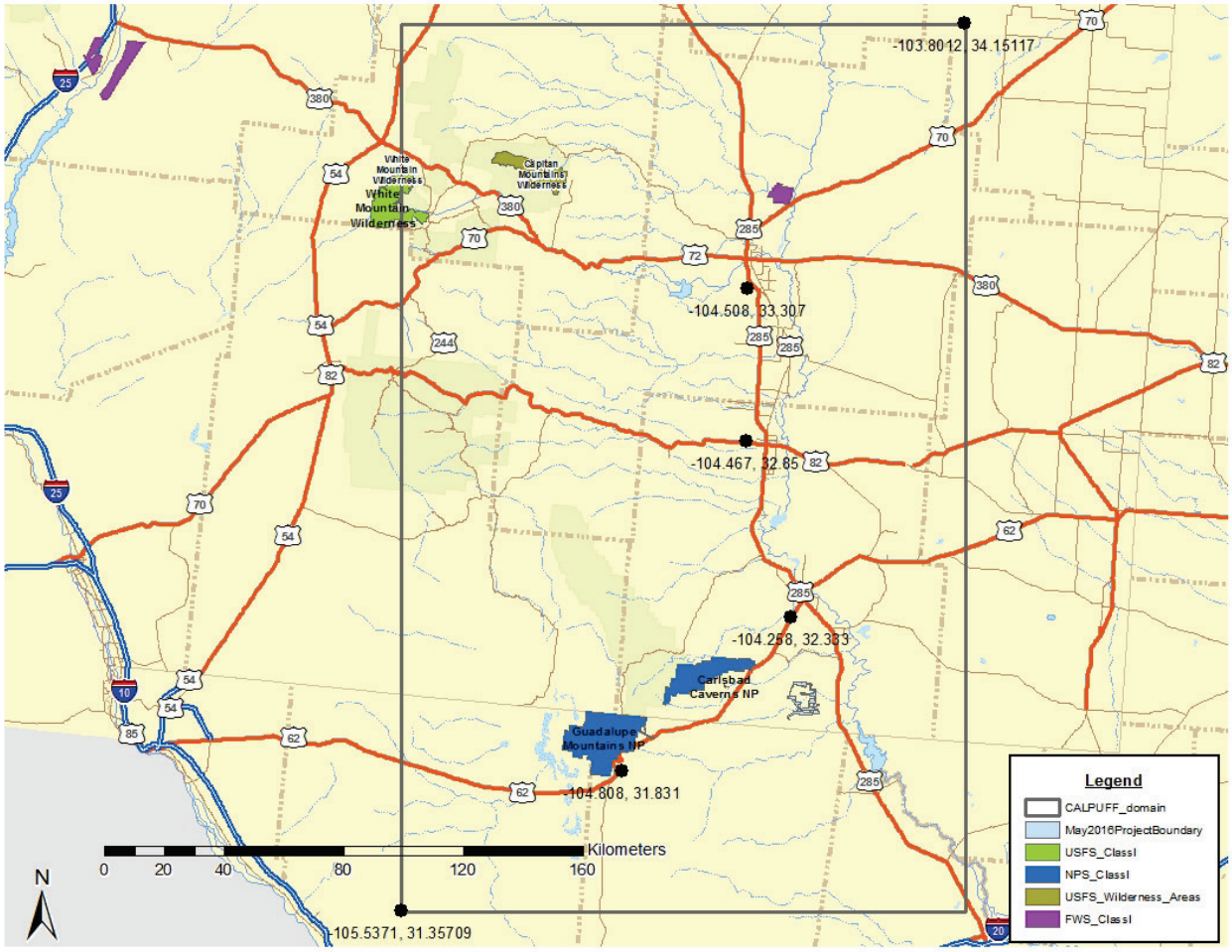

Figure 3-1 Modeling Domain

3.2. Assessment Areas and Receptor Grids

The receptor grids for the Class I areas for this assessment were based on the NPS national database (receptor coordinates and elevations obtained from the NPS database). Additional receptors were placed at occupied structures near the project area. Receptor elevations for nearby occupied structures were derived using National Elevation Dataset (NED) data with 10-m horizontal resolution (USGS, 2000). **Table 2-4** lists each of the Class I and sensitive Class II areas of concern within the modeling domain and they are included in **Figure 3-1**.

3.3. CALPUFF Emission Inputs

The CALPUFF model was used to evaluate the maximum annual emissions from drilling and production operations using three different model simulations. Each simulation considered a scenario representing emission rates at milestones of the proposed development. The maximum emissions from drilling, completion, fracturing, production and transmission activities (as shown in Section 2.0) were scaled based on proposed activity levels per year to determine the worst-case years for modeling.

- Scenario 1 – 2019 Drilling and Completion: This scenario represents maximum drilling emissions only in order to understand the contribution of drilling, completion, and hydraulic fracturing to air quality and AQRV
- Scenario 2 – 2025 Drilling and Production: This scenario represents the highest total annual emissions from the project based on proposed drilling and production levels
- Scenario 3 – 2025 Production: This scenario represents maximum production emissions only in order to understand the contribution of production and transmission to air quality and AQRVs

The study analyzed air quality impact against the NAAQS and AQRVs; therefore, the pollutants of concern are NO_X, CO, SO_2, PM_{10}, and $PM_{2.5}$. **Figure 3-2** shows the predicted annual emissions of NO_X and CO for each modeled pollutant by year. **Figure 3-3** shows the predicted annual emissions of SO_2, PM_{10}, and $PM_{2.5}$ for each modeled year.

The emissions from drilling and development were divided into 4 point sources while the emissions from production were divided into 7 production related point sources. These sources were distributed across the development area as shown in **Figure 3-4**. The modeled emission rates and source parameters are summarized in **Table 3-1**.

Table 3-1 Summary of Point Source Emissions and Modeling Parameters for CALPUFF Modeling

Activity	No. of Sources	Emissions per Source (tpy)	Modeled Emission Rate (g/m^2-s)	Discharge Height (m)	Source Diameter (m)	Discharge Velocity (m/s)	Discharge Temperature (K)
Drilling	4	65.74	1.91×10^{-11}	6.2	0.2	30.0	675
Production	7	21.97	1.15×10^{-11}	6.2	0.2	30.0	675

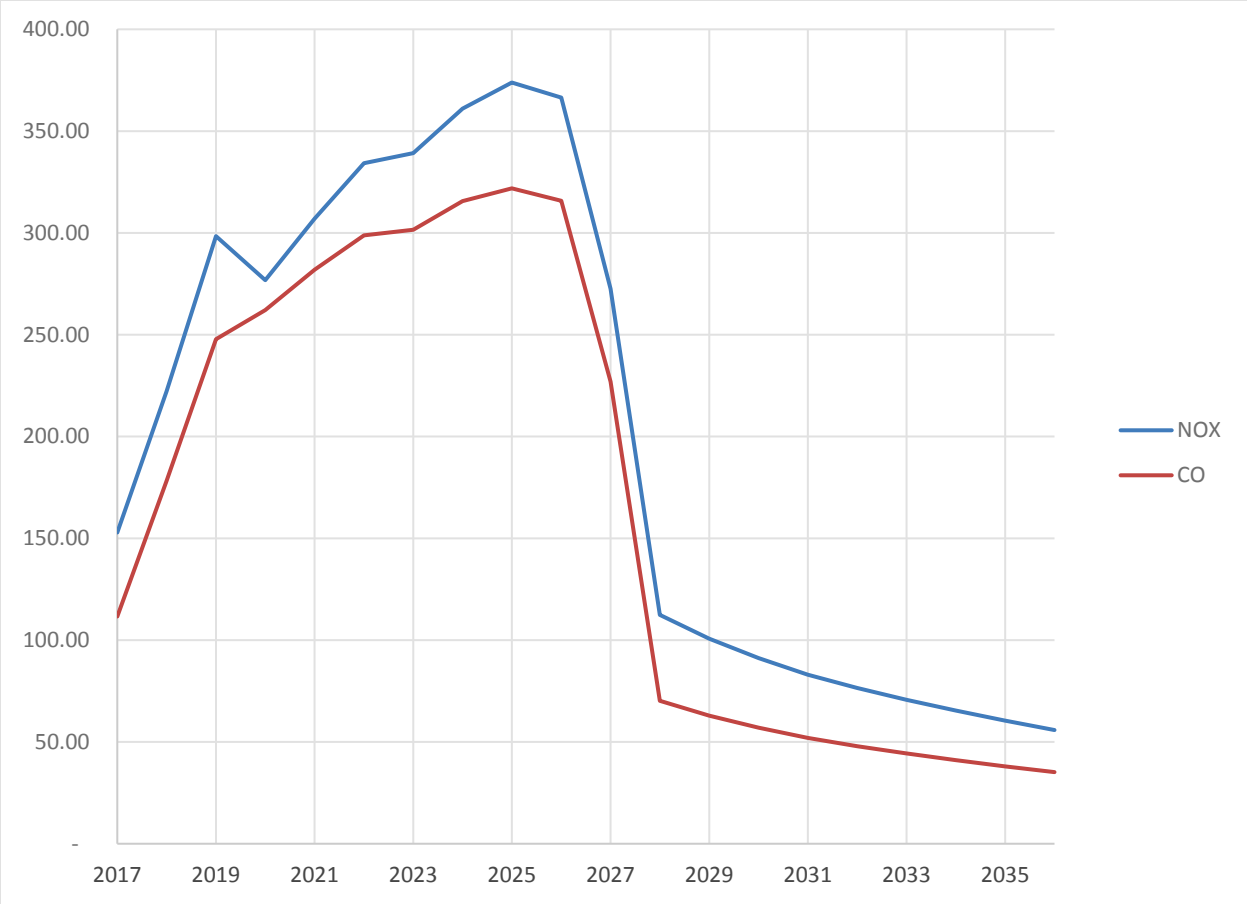

Figure 3-2 Predicted Annual Emissions of NOX and CO (in tons per year) for the Hayhurst Development

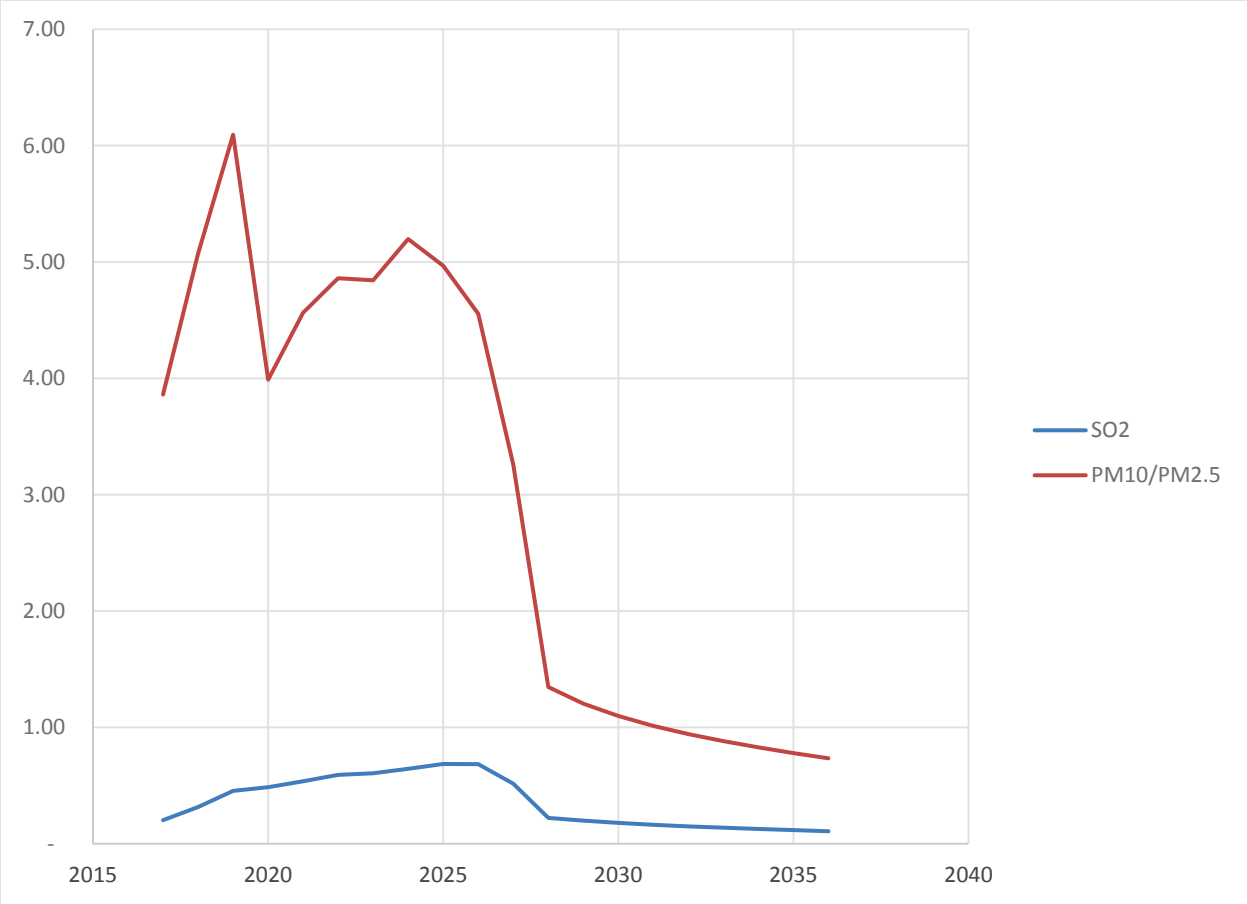

Figure 3-3 Predicted Annual Emissions of SO_2 and $PM_{10}/PM_{2.5}$ (in tons per year) for the Hayhurst Development

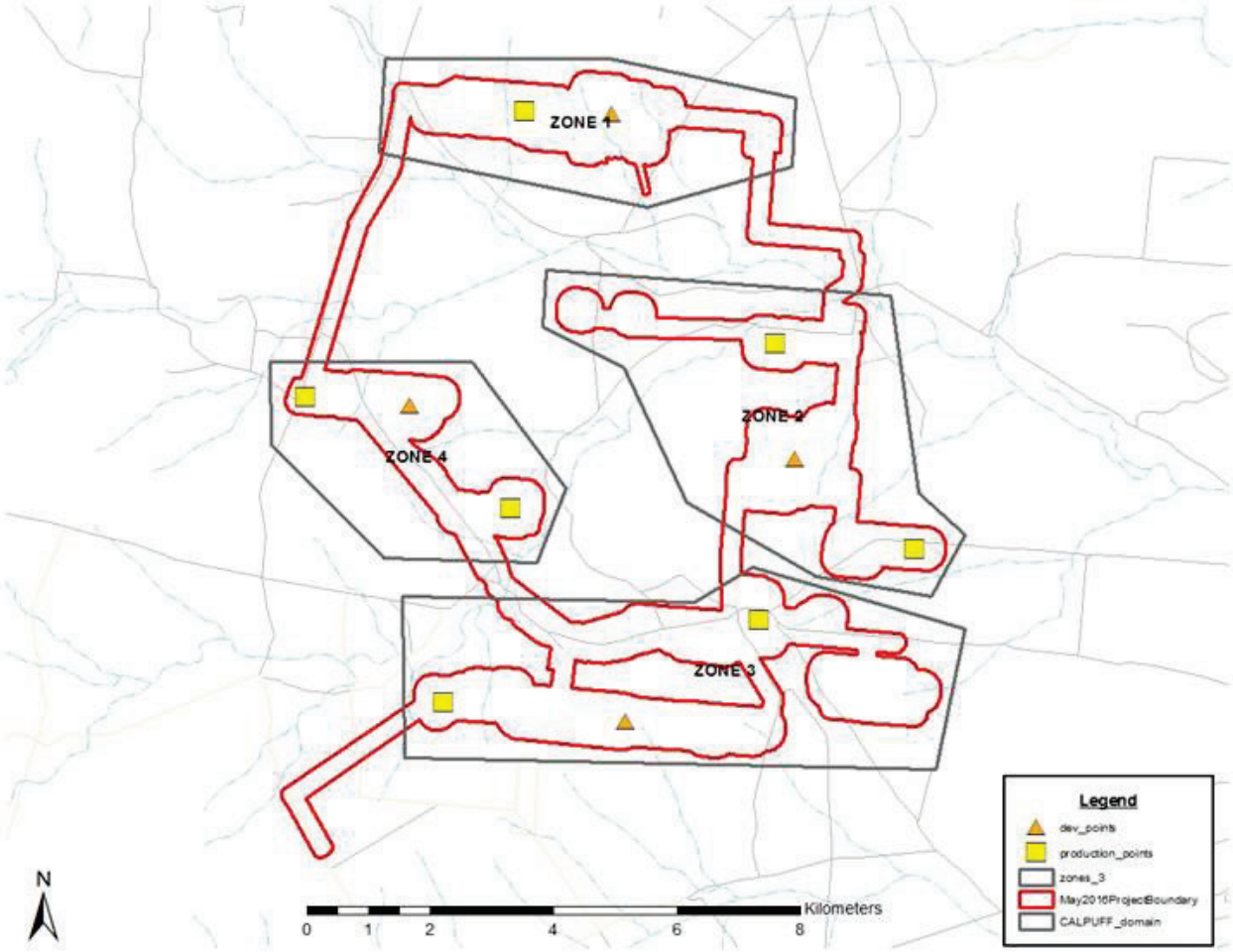

Figure 3-4 Source Layout

3.4. Meteorological Data Development

The CALPUFF meteorological data were generated using the MMIF program version 3.2 dated 07-24-2014.MMIF extracts and formats the necessary meteorological fields for CALPUFF from the Weather WRF simulation using minimal additional processing to maintain the integrity of the WRF simulations. MMIF was run to extract meteorological data at the standard CALPUFF elevations of 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1200 m, 2000 m, 3000 m, and 4000 m. The MMIF extraction used the 4km Westjump 2008 WRF simulation (WestJump AQMS, 2011) the same simulation used in the 2013 CFO Oil and Gas Resource Management Plan Revision.

3.5. CALPUFF Background Air Quality Data

The CALPUFF chemistry algorithms require hourly estimates of background ammonia and ozone concentrations for the conversion of NO/NO_2 and SO_2 to nitrates and sulfates, respectively. Background ozone monitoring data available for the proposed model year (2008) from the ambient monitoring station at Hobbs, NM were included in the CALPUFF analysis. The background monthly average ozone values ranged from 27.6 ppb in December to 56.3 ppb in June (EPA, 2016b). Monthly ammonia values of 1 ppb were used for October to March and 5.0 ppb were used for April to September (USFS et al., 2010).

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4. ASSESSMENT AND REPORTING OF AIR QUALITY IMPACTS

The purpose of the air quality analysis was to assess local and regional air quality impacts from the proposed action. The approach was to develop an emissions inventory for a project base year to tabulate emissions for comparison to emissions estimates and impacts evaluated in the ARTSD prepared in support of the RMP (URS 2013). The ARTSD evaluated impacts of a 20 year projected RFD of oil and gas exploration and production within the CFO area of responsibility. This study found no significant impact from the RFD, and as such, if the proposed action's emission contributions conformed to the ARTSD analysis, then no significant impact is predicted. In cases where emissions did not conform to the ARTSD, additional modeling analysis (as described in Section 3.0) was conducted to characterize impacts.

4.1. Impacts to Ambient Air Quality

As shown in **Table 3-6**, the greatest emissions would occur during the drilling and completion of wells, particularly from diesel-fired engines powering fluid pumps during hydraulic fracturing operations. In particular, the hourly and annual emissions of NO2 would exceed the parameters evaluated in the ARTSD (URS, 2013) as shown in **Table 4-1**. The maximum air pollutant emissions from each well would be temporary (i.e. only occurring during well drilling and completion), would occur in unpopulated areas, and would not significantly interact with adjacent well locations. Given the temporary, transient and remote nature of these emissions, impacts to nearby receptors are not anticipated to be significant. However, due to the proximity of Carlsbad Caverns National Park, impacts to ambient air quality, specifically the hourly NO_2 standards, were evaluated using the CALPUFF modeling system as described in Section 3.0 and found to not contribute to a violation of the NAAQS. Other Class I areas are further from the project area and presumed to have less ambient air quality impact and not modeled. A summary of these impacts are provided in **Table 4-2**.

Table 4-1 Comparison of Drilling and Completion Emissions from the Proposed Action to ARTSD

Activity/ Phase	Proposed Action							ARTSD [1]			
	Power [2]	NO_X Emissions						Power [2]	NO_X Emissions		
		Tier 2			Tier 4						
	(hp)	(g/hp-hr)[3]	(lb/hr)	(ton/ well)	(g/hp-hr)[4]	(lb/ hr)	(ton/ well)	(hp)	(g/hp-hr)[4]	(lb/ hr)	(ton/ well)
Drilling[5]	2,760	4.56	27.7	2.8	2.60	15.8	1.6	1,482	0.3	1.0	0.14
Fracturing and Flowback[6]	19,784	4.56	198.9	6.0	2.60	113.4	3.4	1,336	0.3	0.9	0.13
Completion	750	4.56	7.5	0.1	0.50	0.8	0.01	350	0.3	0.2	0.03
Total	23,294		198.9[7]	8.9		130.0[7]		3,168		1.0[7]	0.30

Notes
1 URS 2013.
2 Maximum hourly load of total engine capacity of multiple engines in simultaneous use.
3 USEPA Tier 2 emission standards for engines greater than 750 hp assuming 95% of non-methane hydrocarbon (NMHC) + NOX based on California Air Resources Board (CARB) "Emissions Factors for Compression Ignition Diesel Engines".
4 USEPA Tier 4 emissions standards.
5 Includes primary drill rig and power generation.
6 Includes engines to power pumps to inject fluids for hydraulic fracturing, blending, and flowback. ARTSD (URS 2013) did not include hydraulic fracturing.
7 Represents maximum hourly emission rate from each phase.

Table 4-2 Summary of 1-hr NO_2 Ambient Air Quality Impacts Near the Project Area

Scenario	Concentration (μg/m³)			Ambient Standard (μg/m³)[3]	Percent of Standard
	Modeled[1]	Background[2]	Total		
Scenario 1 – 2019 Drilling	28.3	34.6	62.9	188	49.5
Scenario 2 – 2025 Production and Drilling	26.6		61.2		32.6
Scenario 3 – 2025 Production	11.6		46.2		24.6

Notes:
1 High 1st High 1-hour used (2008); CALPUFF predicted impacts approximately 2 to 3 kilometers from the Project Area.
2 3-year average of 98th percentile of 1-hour max used (2012-2014) (1 ppb = 1.88 μg/m³) (NMED 2014).
3 National Ambient Air Quality Standard of 100 ppb (1 ppb = 1.88 μg/m³)

4.2. Impacts to Air Quality Related Values (Nitrogen Deposition)

The ARTSD (URS 2013) provided an analysis of acid deposition in nearby Class I areas. However, due the increase in NO_X emissions, CALPUFF modeling was also used to provide updated acid deposition results for nitrates in these Class I areas. **Table 4-3** shows the acid deposition for proposed action scenarios as described in **Section 3.3**. The analysis predicts the incremental impacts from the project would exceed the deposition analysis threshold (DAT) of 0.005 kilogram per hectare-year (kg/ha-yr) in Carlsbad Cavern National Park during drilling operations, but would be well below the DAT once drilling has completed.

Table 4-3 CALPUFF Modeled Results for Nitrogen Deposition in Class I Areas from the Proposed Action

Scenarios	Carlsbad Cavern National Park	Guadalupe Mountains National Park
	(kg/ha-yr)	
Scenario 1 – 2019 Drilling	0.0060	0.0008
Scenario 2 – 2025 Drilling and Production	0.0087	0.0011
Scenario 3 – 2025 Production Only	0.0036	0.0005

Notes:
1 The Deposition Analysis Threshold (DAT) of 0.005 kg/ha-yr is a significance threshold. If the modeled deposition rate (without adding background concentration) is below the DAT, the predicted impacts are considered to be insignificant

As prescribed in Federal Land Managers' Air Quality Related Values Work Group (FLAG) guidance (USFS et al. 2011) an exceedance of the DAT does not necessarily indicate impact, but further consider of acid deposition is required addressing the following criteria:

- Is the affected area sensitive to deposition?
- Is the affected area currently impacted by deposition?
- Have critical loads or target loads been developed for the affected area?
- Does current deposition exceed the critical load or target load?

Carlsbad Caverns contains protected portions of the northern Chihuahuan Desert ecosystem which contains woodland, shrubland, and grassland vegetation types that can be sensitive to nitrogen deposition due to fertilization of non-native species. The NPS has identified two species of invasive grass found within the park, *Bromus rubens* (red brome) and *Avena fatua* (Wild Oats). Research has shown that additional growth can be stimulated at or above 3.0 kg/ha-yr (Rao et al. 2010) to levels that could present an increased risk of wildfire. This coincides with the FLAG guidance cumulative threshold value of 3.0 kg/ha-yr for nitrogen deposition.

The National Atmospheric Deposition Program (NADP) has developed deposition maps based on a combination of monitoring networks supplemented by mesoscale modeling using the Community Multiscale Air Quality (CMAQ) model. This data, as provided by National Park Service, shows deposition levels from 2.7 kg/ha-yr to 3.5 kg/ha-yr (NADP, 2014). However, these values were determined based on CMAQ modeling at 12 km resolution, and actual deposition levels in Carlsbad Cavern National Park have not been monitored. **Table 4-4** shows the predicted nitrogen deposition impacts for each year from 2017-2036.This analysis indicates that predicted impacts from proposed production will be well below the DAT. Contributions from drilling will be at or slightly above the DAT for a period of 8 years during drilling operations, and that cumulative average impact over 20 years will be 0.0046, just below the DAT. The relative contribution from drilling and production compared to the total DAT is provided in **Figure 4-1**.

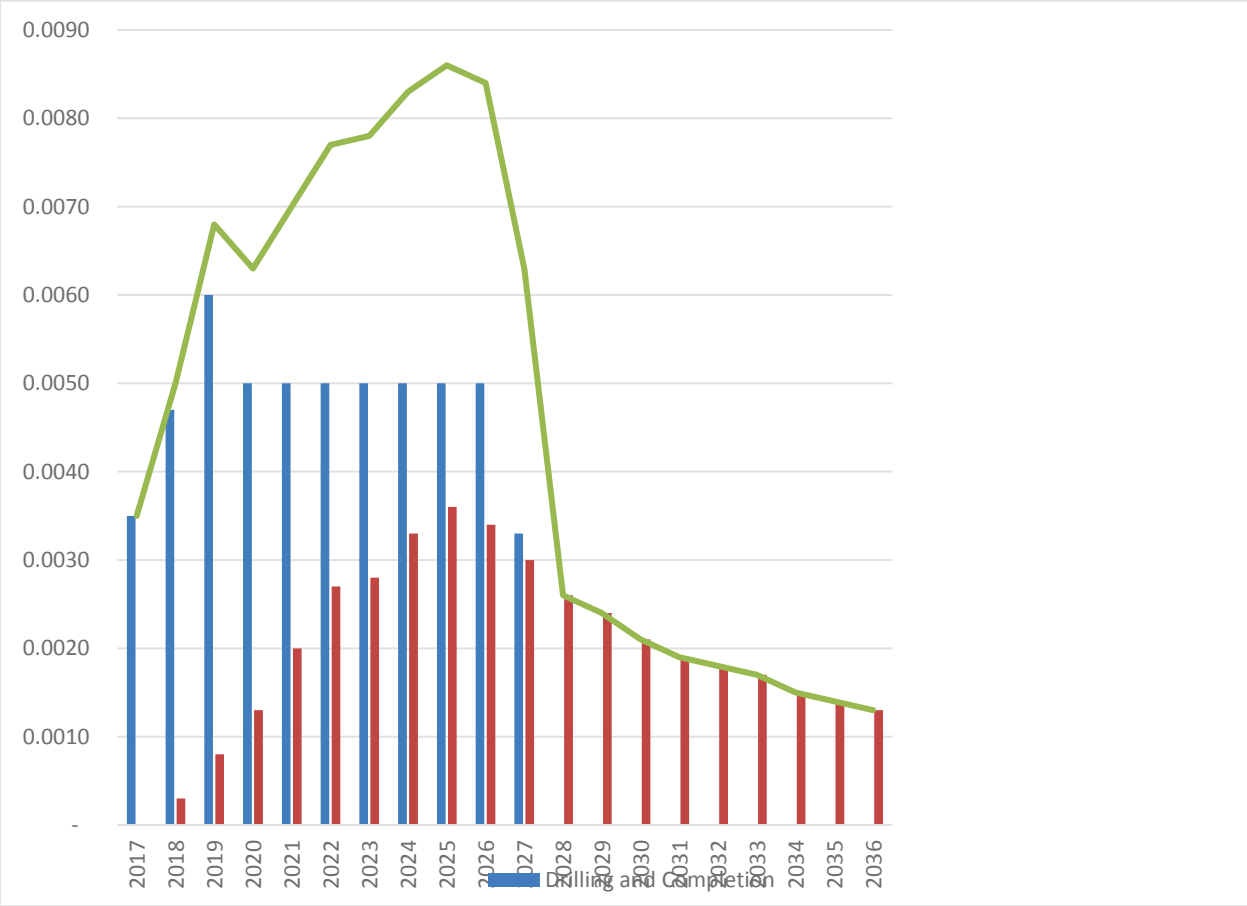

Figure 4-1 Nitrogen Deposition (in kg/ha-yr) at Carlsbad Cavern National Park

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Table 4-4 Predicted Annual Impacts to Nitrogen Deposition (2017-2037)

Emissions per well		DAT Contribution		
NOx Drill Rig - Tier 2 (tons/well) =	2.77	Drilling	0.006	(kg/ha/yr)
NOx Drill Rig - Tier 4 (tons/well) =	1.58		262.95	(tpy)
NOx Completions Rig - Tier 2 (tons/well) =	0.16		2.28E-05	(kg/ha/ton)
NOx Completions Rig - Tier 4 (tons/well) =	0.02			
NOx Hydraulic Fracturing - Tier 2 (tons/well) =	5.97			
NOx Hydraulic Fracturing - Tier 4 (tons/well) =	3.40	Production	0.0036	(kg/ha/yr)
NOx Max Dehydrator Emissions (tpy) =	4.72		153.80	(tpy)
NOx Max Compressor Emissions (tpy) =	114.72		2.34E-05	(kg/ha/ton)
NOx Max Separator Emissions (tpy) =	102.15			

	No. of Wells Drilled		Emissions (tons/year)															DAT Estimation					
			Drilling and Completion				Hydraulic Fracturing		Total Drilling Emissions		Production Emissions							Drilling and Completion					
			Tier 2		Tier 4																		
Year	Tier 2	Tier 4	Drill Rig	Completions Rig	Drill Rig	Completions Rig	Tier 2	Tier 4	Tier 2	Tier 4	Dehydrator Emissions (25% per year)	% Max Gas Production[1]	Compression	% Max Separator Capacity[2]	Separator Heater Emissions	Total Production	TOTAL	Tier 2	Tier 4	Total	Production	Total	% above DAT
2017	11	11	30.52	1.74	17.40	0.19	65.64	37.42	97.90	55.02	-	0.0	-	0.0	-	-	152.92	0.0022	0.0013	0.0035	-	0.0035	-30
2018	11	22	30.52	1.74	34.81	0.38	65.64	74.85	97.90	110.03	1.18	4.1	4.72	8.2	8.37	14.27	222.21	0.0022	0.0025	0.0047	0.0003	0.0050	***0***
2019	11	33	30.52	1.74	52.21	0.57	65.64	112.27	97.90	165.05	2.36	17.2	19.72	13.1	13.42	35.50	298.45	0.0022	0.0038	**0.0060**	0.0008	**0.0068**	***36***
2020	0	44	-	-	69.61	0.76	-	149.69	-	220.07	3.54	28.9	33.11	19.6	20.05	56.70	276.77	-	0.0050	0.0050	0.0013	**0.0063**	***26***
2021	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	47.0	53.90	27.7	28.31	86.94	307.01	-	0.0050	0.0050	0.0020	**0.0070**	***40***
2022	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	66.6	76.42	32.3	33.03	114.18	334.25	-	0.0050	0.0050	0.0027	**0.0077**	***54***
2023	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	71.2	81.73	32.0	32.66	119.11	339.18	-	0.0050	0.0050	0.0028	**0.0078**	***56***
2024	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	85.2	97.79	37.6	38.46	140.97	361.04	-	0.0050	0.0050	0.0033	**0.0083**	***66***
2025	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	100.0	114.72	33.6	34.36	153.80	373.87	-	0.0050	0.0050	0.0036	**0.0086**	***72***
2026	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	99.6	114.27	26.9	27.43	146.42	366.49	-	0.0050	0.0050	0.0034	**0.0084**	***68***
2027	0	29	-	-	45.88	0.50	-	98.66	-	145.05	4.72	89.2	102.32	20.0	20.45	127.49	272.53	-	0.0033	0.0033	0.0030	**0.0063**	***26***
2028	0	0	-	-	-	-	-	-	-	-	4.72	79.2	90.80	16.5	16.85	112.37	112.37	-	-	-	0.0026	0.0026	-48
2029	0	0	-	-	-	-	-	-	-	-	4.72	71.0	81.40	14.2	14.55	100.68	100.68	-	-	-	0.0024	0.0024	-52
2030	0	0	-	-	-	-	-	-	-	-	4.72	64.2	73.63	12.6	12.87	91.22	91.22	-	-	-	0.0021	0.0021	-58
2031	0	0	-	-	-	-	-	-	-	-	4.72	58.2	66.79	11.3	11.53	83.04	83.04	-	-	-	0.0019	0.0019	-62
2032	0	0	-	-	-	-	-	-	-	-	4.72	53.5	61.34	10.2	10.41	76.48	76.48	-	-	-	0.0018	0.0018	-64
2033	0	0	-	-	-	-	-	-	-	-	4.72	49.3	56.52	9.2	9.45	70.69	70.69	-	-	-	0.0017	0.0017	-66
2034	0	0	-	-	-	-	-	-	-	-	4.72	45.4	52.10	8.4	8.59	65.41	65.41	-	-	-	0.0015	0.0015	-70
2035	0	0	-	-	-	-	-	-	-	-	4.72	41.8	47.91	7.6	7.81	60.44	60.44	-	-	-	0.0014	0.0014	-72
2036	0	0	-	-	-	-	-	-	-	-	4.72	38.4	44.00	7.0	7.11	55.84	55.84	-	-	-	0.0013	0.0013	-74

Notes:
Construction emissions are not included since there are no NOx emissions emitted.
1 Gas production as a fraction of maximum project design provided by Chevron (September 8, 2016). Compressor usage is directly proportional to gas production.
2 Separator usage is proportional to oil production relative to design capacity. Max separator usage provided by Chevron (September 8, 2016).

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APPENDIX A

PROJECT-SPECIFIC EMISSIONS CALCULATIONS

Table A-1a Emissions Calculations from Diesel-Fired Drill Rig Engines, Tier 2 Compliant

Drilling Rig Size [1]	2,760	(hp)
Number of Engines [1]	1	
Brake Specific Fuel Consumption (BSFC) [2]	7,000	(Btu/bhp-hr)
Drilling Rig Fuel Consumption [3]	28,000	(gal/well)
Hourly Drill Rig Fuel Consumption [4]	19.32	(MMBtu/hr)
Drill Rig Operating Hours [5]	200	(hr/well)
Fuel Heating Value [6]	137,000	(Btu/gal)
Sulfur Content [7]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Table 1a-1 Criteria Pollutant and HAP Emissions for Drill Rig (Tier 2)

Pollutant		Emission Factor [8, 9]	Emission Rate	
		(g/bhp-hr)	(lb/hr per eng)	(tons/well)
Criteria Pollutant	NOx [10]	4.56	27.75	2.77
	CO	2.60	15.82	1.58
	SO_2 [11]	4.72E-03	2.87E-02	2.87E-03
	PM_{10} / $PM_{2.5}$ [12]	0.15	0.91	9.13E-02
	VOC [10]	0.24	1.46	0.15
HAP	Benzene	1.30E-02	7.90E-02	7.90E-03
	Toluene	9.07E-03	5.52E-02	5.52E-03
	Ethylbenzene	2.27E-03	1.38E-02	1.38E-03
	Xylene	9.12E-03	5.55E-02	5.55E-03
	Formaldehyde	7.01E-02	0.43	4.26E-02
	n-Hexane	1.30E-03	7.90E-03	7.90E-04

Table 1a-2 GHG Emissions for Drill Rig

Pollutant		Emission Factor [13]	Emission Rate	
		(kg/MMBtu)	(lb/hr per eng)	(tons/well)
GHG	CO_2	73.96	3,150.2	315.0
	CH_4	3.00E-03	0.13	1.28E-02
	N_2O	6.00E-04	2.56E-02	2.56E-03
	CO_2e	--	--	316.1

Table 1a-3 Speciated PM Emissions for Drill Rig (Tier 2)

Speciated Pollutant [14]		Emission Rate	
		(lb/hr per eng)	(tons/well)
Speciated	Filterable PM	0.34	3.38E-02
	Condensible PM	0.58	5.75E-02
	Elemental Carbon (EC)	0.17	1.69E-02
	Soils	0.17	1.69E-02
	Sulfate (SO_4)	1.72E-02	1.72E-03
	Organic Carbon (OC)	0.56	0.06

Table A-1a Emissions Calculations from Diesel-Fired Drill Rig Engines, Tier 2 Compliant

Drilling Rig Size [1]	2,760	(hp)
Number of Engines [1]	1	
Brake Specific Fuel Consumption (BSFC) [2]	7,000	(Btu/bhp-hr)
Drilling Rig Fuel Consumption [3]	28,000	(gal/well)
Hourly Drill Rig Fuel Consumption [4]	19.32	(MMBtu/hr)
Drill Rig Operating Hours [5]	200	(hr/well)
Fuel Heating Value [6]	137,000	(Btu/gal)
Sulfur Content [7]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Footnotes:

[1] Based on Chevron's proposed plan of development

[2] Fuel consumption based on AP-42, Section 3.3, "Gasoline and Diesel Industrial Engines", Table 3.3-1 Footnote A.

[3] Based on validated historical fuel consumption records for similar operations as provided by Chevron via email (September 12, 2(

[4] Example calculation: Heat rating (MMBtu/hr) = [rig size (HP) x BSFC (Btu/bhp-hr)] / 1,000,000 (Btu/MMBtu)

[5] Calculated based on total fuel use, engine size and brake-specific fuel consumption. Example calculation: Op hours (hr/well) = [l

[6] Fuel heating value based on AP-42 Appendix A, Typical Parameters of Various Fuels for diesel.

[7] Sulfur content based on U.S. EPA Sulfur standard for ultra-low sulfur diesel of 15 ppmw.

[8] Based on U.S. EPA Tier 2 emission standards for engines greater than or equal to 560 kW (750 hp) in units of g/bhp-hr. Tier 2 st

[9] HAP emission factors are based on U.S. EPA Nonroad Mobile Inventory Model database. Note that the most conservative toxic f

[10] NOx emission factors are based on 95% of the NMHC+NOx emission standard; VOC emission factors are based on 5% of the NMHC+NOx standard. Based on California Air Resources Board (CARB) "Emission Factors for CI Diesel Engines - Percent HC in Relation to NMHC + NOx".

[11] SO_2 emissions based on mass balance based on fuel sulfur.
Example calculation: EF (g SO_2/hp-hr) = BSFC (Btu/hp-hr) x Fuel density (lb/gal) x sulfur content (ppmw) x [64.06/32.06 (lb SO_2/l

[12] $PM_{2.5}$ assumed equivalent to PM_{10}

[13] GHG emission factors are based on the following sources: 40 CFR Part 98, Table C-1 for CO_2 (for distillate fuel oil No. 2) and Table C-2 for CH_4 and N_2O (both for fuel gas). CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[14] Speciated pollutants are for modeling purposes only. Speciations are based on the National Park Service (NPS) "Particulate Matter Speciation" web page for oil-fired combustion turbines. The following speciations apply:
Filterable PM is 37% of total PM;
Condensible PM is 63% of total PM;
Elemental Carbon (EC) is 50% of filterable PM;
Soils are 50% of filterable PM;
Sulfates (SO_4) are 40% of SO_2 and adjusted for differences in molecular weights (multiplied by lb-mol for SO_4/SO_2 = 96/64); and,
Organic Carbon (OC) is the difference of sulfates (SO_4) and condensible PM.

Table A-1b Emissions Calculations from Diesel-Fired Drill Rig Engines, Tier 4 Compliant

Drilling Rig Size [1]	2,760	(hp)
Number of Engines [1]	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Drilling Rig Fuel Consumption [3]	28,000	(gal/well)
Hourly Drill Rig Fuel Consumption [4]	19.32	(MMBtu/hr)
Drill Rig Operating Hours [5]	200	(hr/well)
Fuel Heating Value [6]	137,000	(Btu/gal)
Sulfur Content [7]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Table 1b-1 Criteria Pollutant and HAP Emissions for Drill Rig (Tier 4)

Pollutant		Emission Factor [8, 9]	Emission Rate	
		(g/bhp-hr)	(lb/hr per eng)	(tons/well)
Criteria Pollutant	NOx [10]	2.60	15.82	1.58
	CO	2.60	15.82	1.58
	SO_2 [11]	4.72E-03	2.87E-02	2.87E-03
	PM_{10} / $PM_{2.5}$ [12]	0.03	0.18	1.83E-02
	VOC [10]	0.14	0.85	8.52E-02
HAP	Benzene	7.57E-03	4.61E-02	4.61E-03
	Toluene	5.29E-03	3.22E-02	3.22E-03
	Ethylbenzene	1.32E-03	8.04E-03	8.04E-04
	Xylene	5.32E-03	3.24E-02	3.24E-03
	Formaldehyde	4.09E-02	0.25	2.49E-02
	n-Hexane	7.57E-04	4.61E-03	4.61E-04

Table 1b-2 GHG Emissions for Drill Rig

Pollutant		Emission Factor [13]	Emission Rate	
		(kg/MMBtu)	(lb/hr per eng)	(tons/well)
GHG	CO_2	73.96	3,150.2	315.0
	CH_4	3.00E-03	0.13	1.28E-02
	N_2O	6.00E-04	2.56E-02	2.56E-03
	CO_2e	--	--	316.1

Table 1b-3 Speciated PM Emissions for Drill Rig (Tier 4)

Speciated Pollutant [14]		Emission Rate	
		(lb/hr per eng)	(tons/well)
Speciated	Filterable PM	6.75E-02	6.75E-03
	Condensible PM	0.12	1.15E-02
	Elemental Carbon (EC)	3.38E-02	3.38E-03
	Soils	3.38E-02	3.38E-03
	Sulfate (SO_4)	1.72E-02	1.72E-03
	Organic Carbon (OC)	9.78E-02	0.01

Table A-1b Emissions Calculations from Diesel-Fired Drill Rig Engines, Tier 4 Compliant

Drilling Rig Size [1]	2,760	(hp)
Number of Engines [1]	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Drilling Rig Fuel Consumption [3]	28,000	(gal/well)
Hourly Drill Rig Fuel Consumption [4]	19.32	(MMBtu/hr)
Drill Rig Operating Hours [5]	200	(hr/well)
Fuel Heating Value [6]	137,000	(Btu/gal)
Sulfur Content [7]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Footnotes:

[1] Based on Chevron's proposed plan of development

[2] Fuel consumption based on AP-42, Section 3.3, "Gasoline and Diesel Industrial Engines", Table 3.3-1 Footnote A.

[3] Based on validated historical fuel consumption records for similar operations as provided by Chevron via email (September 12, 2(

[4] Example calculation: Heat rating (MMBtu/hr) = [rig size (HP) x fuel consumption (Btu/bhp-hr)] / 1,000,000

[5] Calculated based on total fuel use, engine size and brake-specific fuel consumption. Example calculation: Op hours (hr/well) = [l

[6] Fuel heating value based on AP-42 Appendix A, Typical Parameters of Various Fuels for diesel.

[7] Sulfur content based on U.S. EPA Sulfur standard for ultra-low sulfur diesel of 15 ppmw.

[8] Based on U.S. EPA Tier 4 emission standards for engines greater than or equal to 560 kW (750 hp) in units of g/bhp-hr. Tier 2 st

[9] HAP emission factors are based on U.S. EPA Nonroad Mobile Inventory Model database. Note that the most conservative toxic f

[10] NOx emission factors are based on 95% of the NMHC+NOx emission standard; VOC emission factors are based on 5% of the NMHC+NOx standard. Based on California Air Resources Board (CARB) "Emission Factors for CI Diesel Engines - Percent HC in Relation to NMHC + NOx".

[11] SO_2 emissions based on mass balance based on fuel sulfur.

Example calculation: EF (g SO_2/hp-hr) = BSFC (Btu/hp-hr) x Fuel density (lb/gal) x sulfur content (ppmw) x [64.06/32.06 (lb SO_2/l

[12] $PM_{2.5}$ assumed equivalent to PM_{10}

[13] GHG emission factors are based on the following sources: 40 CFR Part 98, Table C-1 for CO_2 (for distillate fuel oil No. 2) and Table C-2 for CH_4 and N_2O (both for fuel gas). CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[14] Speciated pollutants are for modeling purposes only. Speciations are based on the National Park Service (NPS) "Particulate Matter Speciation" web page for oil-fired combustion turbines. The following speciations apply:
Filterable PM is 37% of total PM;
Condensible PM is 63% of total PM;
Elemental Carbon (EC) is 50% of filterable PM;
Soils are 50% of filterable PM;
Sulfates (SO_4) are 40% of SO_2 and adjusted for differences in molecular weights (multiplied by lb-mol for SO_4/SO_2 = 96/64); and,
Organic Carbon (OC) is the difference of sulfates (SO_4) and condensible PM.

Table A-2a Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 2 Compliant

Completions Rig Size [1]	750	(hp)
Number of Engines [1]	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Completions Rig Fuel Consumption [3]	1,600	(gal/well)
Hourly Completion Rig Consumption [4]	5.25	(MMBtu/hr)
Completion Rig Operating Hours [5]	42	(hr/well)
Fuel Heating Value [6]	137,000	(Btu/gal)
Sulfur Content [7]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Table 2a-1 Criteria Pollutant and HAP Emissions for Completions Rig (Tier 2)

Pollutant		Emission Factor [8, 9]	Emission Rate	
		(g/bhp-hr)	(lb/hr per eng)	(tons/well)
Criteria Pollutant	NOx [10]	4.56	7.54	0.16
	CO	2.60	4.30	9.03E-02
	SO_2 [11]	4.72E-03	7.81E-03	1.64E-04
	PM_{10} / $PM_{2.5}$ [12]	0.15	0.25	5.21E-03
	VOC [10]	0.24	0.40	8.33E-03
HAP	Benzene	1.30E-02	2.15E-02	4.51E-04
	Toluene	9.07E-03	1.50E-02	3.15E-04
	Ethylbenzene	2.27E-03	3.75E-03	7.87E-05
	Xylene	9.12E-03	1.51E-02	3.17E-04
	Formaldehyde	7.01E-02	1.16E-01	2.43E-03
	n-Hexane	1.30E-03	2.15E-03	4.51E-05

Table 2a-2 GHG Emissions for Completions Rig

Pollutant		Emission Factor [13]	Emission Rate	
		(kg/MMBtu)	(lb/hr per eng)	(tons/well)
GHG	CO_2	73.96	856	18.0
	CH_4	3.00E-03	3.47E-02	7.29E-04
	N_2O	6.00E-04	6.94E-03	1.46E-04
	CO_2e	--	--	18.0

Table 2a-3 Speciated PM Emissions for Completions Rig (Tier 2)

Speciated Pollutant [14]		Emission Rate	
		(lb/hr per eng)	(tons/well)
Speciated	Filterable PM	9.18E-02	1.93E-03
	Condensible PM	0.16	3.28E-03
	Elemental Carbon (EC)	4.59E-02	9.64E-04
	Soils	4.59E-02	9.64E-04
	Sulfate (SO_4)	4.69E-03	9.84E-05
	Organic Carbon (OC)	0.15	3.18E-03

Table A-2a Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 2 Compliant

Completions Rig Size [1]	750	(hp)
Number of Engines [1]	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Completions Rig Fuel Consumption [3]	1,600	(gal/well)
Hourly Completion Rig Consumption [4]	5.25	(MMBtu/hr)
Completion Rig Operating Hours [5]	42	(hr/well)
Fuel Heating Value [6]	137,000	(Btu/gal)
Sulfur Content [7]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Footnotes:

[1] Based on Chevron's proposed plan of development

[2] Fuel consumption based on AP-42, Section 3.3, "Gasoline and Diesel Industrial Engines", Table 3.3-1 Footnote A.

[3] Based on validated historical fuel consumption records for similar operations as provided by Chevron via email (September 12, 2016).

[4] Example calculation: Heat rating (MMBtu/hr) = [rig size (HP) x BSFC (Btu/bhp-hr)] / 1,000,000 (Btu/MMBtu)

[5] Calculated based on total fuel use, engine size and brake-specific fuel consumption. Example calculation: Op hours (hr/well) = [fuel consump

[6] Fuel heating value based on AP-42 Appendix A, Typical Parameters of Various Fuels for diesel.

[7] Sulfur content based on U.S. EPA Sulfur standard for ultra-low sulfur diesel of 15 ppmw.

[8] Based on U.S. EPA Tier 2 emission standards for engines greater than or equal to 560 kW (750 hp) in units of g/bhp-hr. Tier 2 standards wer

[9] HAP emission factors are based on U.S. EPA Nonroad Mobile Inventory Model database. Note that the most conservative toxic fractions wer

[10] NOx emission factors are based on 95% of the NMHC+NOx emission standard; VOC emission factors are based on 5% of the NMHC+NOx standard. Based on California Air Resources Board (CARB) "Emission Factors for CI Diesel Engines - Percent HC in Relation to NMHC + NOx".

[11] SO_2 emissions based on mass balance based on fuel sulfur.
Example calculation: EF (g SO_2/hp-hr) = BSFC (Btu/hp-hr) x Fuel density (lb/gal) x sulfur content (ppmw) x [64.06/32.06 (lb SO_2/lb S)] x 453.5

[12] $PM_{2.5}$ assumed equivalent to PM_{10}

[13] GHG emission factors are based on the following sources: 40 CFR Part 98, Table C-1 for CO_2 (for distillate fuel oil No. 2) and Table C-2 for CH_4 and N_2O (both for fuel gas). CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[14] Speciated pollutants are for modeling purposes only. Speciations are based on the National Park Service (NPS) "Particulate Matter Speciation" web page for oil-fired combustion turbines. The following speciations apply:
Filterable PM is 37% of total PM;
Condensible PM is 63% of total PM;
Elemental Carbon (EC) is 50% of filterable PM;
Soils are 50% of filterable PM;
Sulfates (SO_4) are 40% of SO_2 and adjusted for differences in molecular weights (multiplied by lb-mol for SO_4/SO_2 = 96/64); and,
Organic Carbon (OC) is the difference of sulfates (SO_4) and condensible PM.

Table A-2b Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 4 Compliant

Completions Rig Size [1]	750	(hp)
Number of Engines [1]	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Completions Rig Fuel Consumption [3]	1,600	(gal/well)
Hourly Completion Rig Consumption [4]	5.25	(MMBtu/hr)
Completion Rig Operating Hours [5]	42	(hr/well)
Fuel Heating Value [6]	137,000	(Btu/gal)
Sulfur Content [7]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Table 2b-1 Criteria Pollutant and HAP Emissions for Completions Rig (Tier 2)

Pollutant		Emission Factor [8, 9]	Emission Rate	
		(g/bhp-hr)	(lb/hr per eng)	(tons/well)
Criteria Pollutant	NOx [10]	0.50	0.83	1.74E-02
	CO	2.60	4.30	9.03E-02
	SO_2 [11]	4.72E-03	7.81E-03	1.64E-04
	PM_{10} / $PM_{2.5}$ [12]	0.022	3.64E-02	7.64E-04
	VOC [10]	0.14	0.23	4.86E-03
HAP	Benzene	7.57E-03	1.25E-02	2.63E-04
	Toluene	5.29E-03	8.75E-03	1.84E-04
	Ethylbenzene	1.32E-03	2.19E-03	4.59E-05
	Xylene	5.32E-03	8.80E-03	1.85E-04
	Formaldehyde	4.09E-02	6.76E-02	1.42E-03
	n-Hexane	7.57E-04	1.25E-03	2.63E-05

Table 2b-2 GHG Emissions for Completions Rig

Pollutant		Emission Factor [13]	Emission Rate	
		(kg/MMBtu)	(lb/hr per eng)	(tons/well)
GHG	CO_2	73.96	856	18.0
	CH_4	3.00E-03	3.47E-02	7.29E-04
	N_2O	6.00E-04	6.94E-03	1.46E-04
	CO_2e	--	--	18.0

Table 2a-3 Speciated PM Emissions for Completions Rig (Tier 2)

Speciated Pollutant [14]		Emission Rate	
		(lb/hr per eng)	(tons/well)
Speciated	Filterable PM	1.35E-02	2.83E-04
	Condensible PM	2.29E-02	4.81E-04
	Elemental Carbon (EC)	6.73E-03	1.41E-04
	Soils	6.73E-03	1.41E-04
	Sulfate (SO_4)	4.69E-03	9.84E-05
	Organic Carbon (OC)	1.82E-02	3.83E-04

Table A-2b Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 4 Compliant

Completions Rig Size [1]	750	(hp)
Number of Engines [1]	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Completions Rig Fuel Consumption [3]	1,600	(gal/well)
Hourly Completion Rig Consumption [4]	5.25	(MMBtu/hr)
Completion Rig Operating Hours [5]	42	(hr/well)
Fuel Heating Value [6]	137,000	(Btu/gal)
Sulfur Content [7]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Footnotes:

[1] Based on Chevron's proposed plan of development

[2] Fuel consumption based on AP-42, Section 3.3, "Gasoline and Diesel Industrial Engines", Table 3.3-1 Footnote A.

[3] Based on historical fuel consumption records provided by Chevron

[4] Example calculation: Heat rating (MMBtu/hr) = [rig size (HP) x fuel consumption (Btu/bhp-hr)] / 1,000,000

[5] Estimated based on total fuel use, engine size and brake-specific fuel concumption

[6] Fuel heating value based on AP-42 Appendix A, Typical Parameters of Various Fuels for diesel.

[7] Sulfur content based on U.S. EPA Sulfur standard for ultra-low sulfur diesel of 15 ppmw.

[8] Based on U.S. EPA Tier 4 emission standards for engines greater than or equal to 560 kW (750 hp) in units of g/bhp-hr. Tier 2 standards were developed in 2006.

[9] HAP emission factors are based on U.S. EPA Nonroad Mobile Inventory Model database. Note that the most conservative toxic fractions were chosen for these emissions calculations depending on the engine standard.

[10] NOx emission factors are based on 95% of the NMHC+NOx emission standard; VOC emission factors are based on 5% of the NMHC+NOx standard. Based on California Air Resources Board (CARB) "Emission Factors for CI Diesel Engines - Percent HC in Relation to NMHC + NOx".

[11] SO_2 emissions based on mass balance based on fuel sulfur.
Example calculation: EF (g SO_2/hp-hr) = BSFC (Btu/hp-hr) x Fuel density (lb/gal) x sulfur content (ppmw) x [64.06/32.06 (lb SO_2/lb S)] x 453.5

[12] $PM_{2.5}$ assumed equivalent to PM_{10}

[13] GHG emission factors are based on the following sources: 40 CFR Part 98, Table C-1 for CO_2 (for distillate fuel oil No. 2) and Table C-2 for CH_4 and N_2O (both for fuel gas). CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[14] Speciated pollutants are for modeling purposes only. Speciations are based on the National Park Service (NPS) "Particulate Matter Speciation" web page for oil-fired combustion turbines. The following speciations apply:
Filterable PM is 37% of total PM;
Condensible PM is 63% of total PM;
Elemental Carbon (EC) is 50% of filterable PM;
Soils are 50% of filterable PM;
Sulfates (SO_4) are 40% of SO_2 and adjusted for differences in molecular weights (multiplied by lb-mol for SO_4/SO_2 = 96/64); and,
Organic Carbon (OC) is the difference of sulfates (SO_4) and condensible PM.

Table A-3a Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 2 Compliant

Main Frac Pump Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	43.6%	
Operating Engine Capacity	980.4	(hp)
Number of Engines	16	
Pump Down Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	58.8%	
Operating Engine Capacity	1,324	(hp)
Number of Engines	2	
Blend Deck Specifications [1]		
Blender Engine #1 Size	850	(hp)
Number of Engines	1	
Blender Engine #2 Size	600	(hp)
Number of Engines	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Main Frac Pump [3]	6.86	(MMBtu/hr)
Pump Down [3]	9.27	(MMBtu/hr)
Blend Engine #1 [3]	5.95	(MMBtu/hr)
Blend Engine #2 [3]	4.20	(MMBtu/hr)
Number of Stages [1]	40	(stages/well)
Main Frac Pump Operating Hours [1]	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Pump Down Operating Hours [1]	0.33	(hr/engine-stage)
	13	(hr/engine-well)
Blend Engine Operating Hours	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Fuel Heating Value [4]	137,000	(Btu/gal)
Sulfur Content [5]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Table 3a-1 Criteria Pollutant and HAP Emissions for Hydraulic Fracturing Engines (Tier 2)

	Pollutant	Emission Factor [6, 7]	Emission Ra				
			Main Frac Pumps		Pump Down		Blend E
		(g/bhp-hr)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)
Criteria Pollutant	NOx [8]	4.56	9.86	4.73	13.31	0.80	8.55
	CO	2.60	5.62	2.70	7.59	0.46	4.87
	SO_2 [9]	4.72E-03	1.02E-02	4.90E-03	1.38E-02	8.27E-04	8.85E-03
	PM_{10} / $PM_{2.5}$ [10]	0.15	0.32	0.16	0.44	2.63E-02	0.28
	VOC [8]	0.24	0.52	0.25	0.70	4.20E-02	0.45
HAP	Benzene	1.30E-02	2.81E-02	1.35E-02	3.79E-02	2.27E-03	2.43E-02
	Toluene	9.07E-03	1.96E-02	9.41E-03	2.65E-02	1.59E-03	1.70E-02
	Ethylbenzene	2.27E-03	4.90E-03	2.35E-03	6.61E-03	3.97E-04	4.25E-03
	Xylene	9.12E-03	1.97E-02	9.46E-03	2.66E-02	1.60E-03	1.71E-02
	Formaldehyde	7.01E-02	0.15	7.27E-02	0.20	1.23E-02	0.13
	n-Hexane	1.30E-03	2.81E-03	1.35E-03	3.79E-03	2.27E-04	2.43E-03

Table 3a-2 GHG Emissions for Hydraulic Fracturing Engines

	Pollutant	Emission Factor [11]	Emission Ra				
			Main Frac Pumps		Pump Down		Blend E
		(kg/MMBtu)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)
GHG	CO_2	73.96	1,119.0	537.1	1,511.2	90.7	970.2
	CH_4	3.00E-03	4.54E-02	2.18E-02	4.54E-02	2.72E-03	3.94E-02
	N_2O	6.00E-04	9.08E-03	4.36E-03	9.08E-03	5.45E-04	7.87E-03

Table A-3a Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 2 Compliant

Main Frac Pump Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	43.6%	
Operating Engine Capacity	980.4	(hp)
Number of Engines	16	
Pump Down Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	58.8%	
Operating Engine Capacity	1,324	(hp)
Number of Engines	2	
Blend Deck Specifications [1]		
Blender Engine #1 Size	850	(hp)
Number of Engines	1	
Blender Engine #2 Size	600	(hp)
Number of Engines	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Main Frac Pump [3]	6.86	(MMBtu/hr)
Pump Down [3]	9.27	(MMBtu/hr)
Blend Engine #1 [3]	5.95	(MMBtu/hr)
Blend Engine #2 [3]	4.20	(MMBtu/hr)
Number of Stages [1]	40	(stages/well)
Main Frac Pump Operating Hours [1]	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Pump Down Operating Hours [1]	0.33	(hr/engine-stage)
	13	(hr/engine-well)
Blend Engine Operating Hours	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Fuel Heating Value [4]	137,000	(Btu/gal)
Sulfur Content [5]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

	CO_2e	--	--	539.0	--	90.9	--

Table3a-3 Speciated PM Emissions for Hydraulic Fracturing Engines

Speciated Pollutant [12]		Emission Rate					
		Main Frac Pumps		Pump Down		Blend Engine #1	
		(lb/hr per eng)	(tons/well)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)	(tons/well)
Speciated	Filterable PM	0.12	5.76E-02	0.16	9.72E-03	1.04E-01	3.12E-03
	Condensible PM	0.20	9.80E-02	0.26	1.56E-02	0.18	5.31E-03
	Elemental Carbon (EC)	6.00E-02	2.88E-02	1.40E-02	8.41E-04	5.20E-02	1.56E-03
	Soils	6.00E-02	2.88E-02	9.80E-03	5.88E-04	5.20E-02	1.56E-03
	Sulfate (SO_4)	6.13E-03	2.94E-03	2.45E-03	1.47E-04	5.31E-03	1.59E-04
	Organic Carbon (OC)	0.20	9.51E-02	9.85E-03	5.91E-04	0.17	5.15E-03

Table A-3a Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 2 Compliant

Main Frac Pump Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	43.6%	
Operating Engine Capacity	980.4	(hp)
Number of Engines	16	
Pump Down Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	58.8%	
Operating Engine Capacity	1,324	(hp)
Number of Engines	2	
Blend Deck Specifications [1]		
Blender Engine #1 Size	850	(hp)
Number of Engines	1	
Blender Engine #2 Size	600	(hp)
Number of Engines	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Main Frac Pump [3]	6.86	(MMBtu/hr)
Pump Down [3]	9.27	(MMBtu/hr)
Blend Engine #1 [3]	5.95	(MMBtu/hr)
Blend Engine #2 [3]	4.20	(MMBtu/hr)
Number of Stages [1]	40	(stages/well)
Main Frac Pump Operating Hours [1]	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Pump Down Operating Hours [1]	0.33	(hr/engine-stage)
	13	(hr/engine-well)
Blend Engine Operating Hours	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Fuel Heating Value [4]	137,000	(Btu/gal)
Sulfur Content [5]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Footnotes:

[1] Based on Chevron's proposed plan of development

[2] Fuel consumption based on AP-42, Section 3.3, "Gasoline and Diesel Industrial Engines", Table 3.3-1 Footnote A.

[3] Example calculation: Heat rating (MMBtu/hr) = [rig size (HP) x fuel consumption (Btu/bhp-hr)] / 1,000,000

[4] Fuel heating value based on AP-42 Appendix A, Typical Parameters of Various Fuels for diesel.

[5] Sulfur content based on U.S. EPA Sulfur standard for ultra-low sulfur diesel of 15 ppmw.

[6] Based on U.S. EPA Tier 2 emission standards for engines greater than or equal to 560 kW (750 hp) in units of g/bhp-hr. Tier 2 standards were developed in 2006.

[7] HAP emission factors are based on U.S. EPA Nonroad Mobile Inventory Model database. Note that the most conservative toxic fractions were chosen for these emissions calculations depending on the engine standard.

[8] NOx emission factors are based on 95% of the NMHC+NOx emission standard; VOC emission factors are based on 5% of the NMHC+NOx standard. Based on California Air Resources Board (CARB) "Emission Factors for CI Diesel Engines - Percent HC in Relation to NMHC + NOx".

[9] SO_2 emissions based on mass balance and 15 ppm diesel fuel with a BSFC of 7,000 Btu/hp-hr.
Example calculation: EF (g SO_2/hp-hr) = BSFC (Btu/hp-hr) x Fuel density (lb/gal) x sulfur content (ppmw) x [64.06/32.06 (lb SO_2/lb S)] x 453.5924 (g SO

[10] $PM_{2.5}$ assumed equivalent to PM_{10}

[11] GHG emission factors are based on the following sources: 40 CFR Part 98, Table C-1 for CO_2 (for distillate fuel oil No. 2) and Table C-2 for CH_4 and N_2O (both for fuel gas). CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

Table A-3a Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 2 Compliant

Main Frac Pump Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	43.6%	
Operating Engine Capacity	980.4	(hp)
Number of Engines	16	
Pump Down Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	58.8%	
Operating Engine Capacity	1,324	(hp)
Number of Engines	2	
Blend Deck Specifications [1]		
Blender Engine #1 Size	850	(hp)
Number of Engines	1	
Blender Engine #2 Size	600	(hp)
Number of Engines	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Main Frac Pump [3]	6.86	(MMBtu/hr)
Pump Down [3]	9.27	(MMBtu/hr)
Blend Engine #1 [3]	5.95	(MMBtu/hr)
Blend Engine #2 [3]	4.20	(MMBtu/hr)
Number of Stages [1]	40	(stages/well)
Main Frac Pump Operating Hours [1]	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Pump Down Operating Hours [1]	0.33	(hr/engine-stage)
	13	(hr/engine-well)
Blend Engine Operating Hours	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Fuel Heating Value [4]	137,000	(Btu/gal)
Sulfur Content [5]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

[12] Speciated pollutants are for modeling purposes only. Speciations are based on the National Park Service (NPS) "Particulate Matter Speciation" web page for oil-fired combustion turbines. The following speciations apply:
Filterable PM is 37% of total PM;
Condensible PM is 63% of total PM;
Elemental Carbon (EC) is 50% of filterable PM;
Soils are 50% of filterable PM;
Sulfates (SO_4) are 40% of SO_2 and adjusted for differences in molecular weights (multiplied by lb-mol for SO_4/SO_2 = 96/64); and, Organic Carbon (OC) is the difference of sulfates (SO_4) and condensible PM.

Table A-3b Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 4 Compliant

Main Frac Pump Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	43.6%	
Operating Engine Capacity	980.4	(hp)
Number of Engines	16	
Pump Down Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	58.8%	
Operating Engine Capacity	1,324	(hp)
Number of Engines	2	
Blend Deck Specifications [1]		
Blender Engine #1 Size	850	(hp)
Number of Engines	1	
Blender Engine #2 Size	600	(hp)
Number of Engines	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Main Frac Pump [3]	6.86	(MMBtu/hr)
Pump Down [3]	9.27	(MMBtu/hr)
Blend Engine #1 [3]	5.95	(MMBtu/hr)
Blend Engine #2 [3]	4.20	(MMBtu/hr)
Number of Stages [1]	40	(stages/well)
Main Frac Pump Operating Hours [1]	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Pump Down Operating Hours [1]	0.33	(hr/engine-stage)
	13	(hr/engine-well)
Blend Engine Operating Hours	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Fuel Heating Value [4]	137,000	(Btu/gal)
Sulfur Content [5]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Table 3b-1 Criteria Pollutant and HAP Emissions for Hydraulic Fracturing Engines (Tier 2)

	Pollutant	Emission Factor [6, 7]	Emission Ra				
			Main Frac Pumps		Pump Down		Blend E
		(g/bhp-hr)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)
Criteria Pollutant	NOx [8]	2.60	5.62	2.70	7.59	0.46	4.87
	CO	2.60	5.62	2.70	7.59	0.46	4.87
	SO_2 [9]	4.72E-03	1.02E-02	4.90E-03	1.38E-02	8.27E-04	8.85E-03
	PM_{10} / $PM_{2.5}$ [10]	0.03	6.48E-02	3.11E-02	8.76E-02	5.25E-03	5.62E-02
	VOC [8]	0.14	0.30	0.15	0.41	2.45E-02	0.26
HAP	Benzene	7.57E-03	1.64E-02	7.86E-03	2.21E-02	1.33E-03	1.42E-02
	Toluene	5.29E-03	1.14E-02	5.49E-03	1.54E-02	9.27E-04	9.92E-03
	Ethylbenzene	1.32E-03	2.86E-03	1.37E-03	3.86E-03	2.31E-04	2.48E-03
	Xylene	5.32E-03	1.15E-02	5.52E-03	1.55E-02	9.32E-04	9.97E-03
	Formaldehyde	4.09E-02	8.84E-02	4.24E-02	1.19E-01	7.16E-03	7.66E-02
	n-Hexane	7.57E-04	1.64E-03	7.86E-04	2.21E-03	1.33E-04	1.42E-03

Table 3b-2 GHG Emissions for Hydraulic Fracturing Engines

	Pollutant	Emission Factor [11]	Emission Ra				
			Main Frac Pumps		Pump Down		Blend E
		(kg/MMBtu)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)
GHG	CO_2	73.96	1,119.0	537.1	1,511.2	90.7	970.2
	CH_4	3.00E-03	4.54E-02	2.18E-02	4.54E-02	2.72E-03	3.94E-02
	N_2O	6.00E-04	9.08E-03	4.36E-03	9.08E-03	5.45E-04	7.87E-03

Table A-3b Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 4 Compliant

Main Frac Pump Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	43.6%	
Operating Engine Capacity	980.4	(hp)
Number of Engines	16	
Pump Down Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	58.8%	
Operating Engine Capacity	1,324	(hp)
Number of Engines	2	
Blend Deck Specifications [1]		
Blender Engine #1 Size	850	(hp)
Number of Engines	1	
Blender Engine #2 Size	600	(hp)
Number of Engines	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Main Frac Pump [3]	6.86	(MMBtu/hr)
Pump Down [3]	9.27	(MMBtu/hr)
Blend Engine #1 [3]	5.95	(MMBtu/hr)
Blend Engine #2 [3]	4.20	(MMBtu/hr)
Number of Stages [1]	40	(stages/well)
Main Frac Pump Operating Hours [1]	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Pump Down Operating Hours [1]	0.33	(hr/engine-stage)
	13	(hr/engine-well)
Blend Engine Operating Hours	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Fuel Heating Value [4]	137,000	(Btu/gal)
Sulfur Content [5]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

	CO_2e	--	--	539.0	--	90.9	--

Table3b-3 Speciated PM Emissions for Hydraulic Fracturing Engines

Speciated Pollutant [12]		Emission Rate					
		Main Frac Pumps		Pump Down		Blend Engine #1	
		(lb/hr per eng)	(tons/well)	(lb/hr per eng)	(tons/well)	(lb/hr per eng)	(tons/well)
Speciated	Filterable PM	2.40E-02	1.15E-02	3.24E-02	1.94E-03	2.08E-02	6.24E-04
	Condensible PM	4.09E-02	1.96E-02	0.15	9.07E-03	3.54E-02	1.06E-03
	Elemental Carbon (EC)	1.20E-02	5.76E-03	8.18E-03	4.91E-04	1.04E-02	3.12E-04
	Soils	1.20E-02	5.76E-03	5.72E-03	3.43E-04	1.04E-02	3.12E-04
	Sulfate (SO_4)	6.13E-03	2.94E-03	1.43E-03	8.56E-05	5.31E-03	1.59E-04
	Organic Carbon (OC)	3.47E-02	1.67E-02	5.75E-03	3.45E-04	3.01E-02	9.03E-04

Table A-3b Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 4 Compliant

Main Frac Pump Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	43.6%	
Operating Engine Capacity	980.4	(hp)
Number of Engines	16	
Pump Down Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	58.8%	
Operating Engine Capacity	1,324	(hp)
Number of Engines	2	
Blend Deck Specifications [1]		
Blender Engine #1 Size	850	(hp)
Number of Engines	1	
Blender Engine #2 Size	600	(hp)
Number of Engines	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Main Frac Pump [3]	6.86	(MMBtu/hr)
Pump Down [3]	9.27	(MMBtu/hr)
Blend Engine #1 [3]	5.95	(MMBtu/hr)
Blend Engine #2 [3]	4.20	(MMBtu/hr)
Number of Stages [1]	40	(stages/well)
Main Frac Pump Operating Hours [1]	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Pump Down Operating Hours [1]	0.33	(hr/engine-stage)
	13	(hr/engine-well)
Blend Engine Operating Hours	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Fuel Heating Value [4]	137,000	(Btu/gal)
Sulfur Content [5]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

Footnotes:

[1] Based on Chevron's proposed plan of development

[2] Fuel consumption based on AP-42, Section 3.3, "Gasoline and Diesel Industrial Engines", Table 3.3-1 Footnote A.

[3] Example calculation: Heat rating (MMBtu/hr) = [rig size (HP) x fuel consumption (Btu/bhp-hr)] / 1,000,000

[4] Fuel heating value based on AP-42 Appendix A, Typical Parameters of Various Fuels for diesel.

[5] Sulfur content based on U.S. EPA Sulfur standard for ultra-low sulfur diesel of 15 ppmw.

[6] Based on U.S. EPA Tier 4 emission standards for engines greater than or equal to 560 kW (750 hp) in units of g/bhp-hr. Tier 2 standards were developed in 2006.

[7] HAP emission factors are based on U.S. EPA Nonroad Mobile Inventory Model database. Note that the most conservative toxic fractions were chosen for these emissions calculations depending on the engine standard.

[8] NOx emission factors are based on 95% of the NMHC+NOx emission standard; VOC emission factors are based on 5% of the NMHC+NOx standard. Based on California Air Resources Board (CARB) "Emission Factors for CI Diesel Engines - Percent HC in Relation to NMHC + NOx".

[9] SO_2 emissions based on mass balance and 15 ppm diesel fuel with a BSFC of 7,000 Btu/hp-hr.
Example calculation: EF (g SO_2/hp-hr) = BSFC (Btu/hp-hr) x Fuel density (lb/gal) x sulfur content (ppmw) x [64.06/32.06 (lb SO_2/lb S)] x 453.5924 (g SO

[10] $PM_{2.5}$ assumed equivalent to PM_{10}

[11] GHG emission factors are based on the following sources: 40 CFR Part 98, Table C-1 for CO_2 (for distillate fuel oil No. 2) and Table C-2 for CH_4 and N_2O (both for fuel gas). CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

Table A-3b Emissions Calculations from Diesel-Fired Completion Rig Engines, Tier 4 Compliant

Main Frac Pump Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	43.6%	
Operating Engine Capacity	980.4	(hp)
Number of Engines	16	
Pump Down Specifications [1]		
Maximum Engine Size	2,250	(hp)
Operating Load	58.8%	
Operating Engine Capacity	1,324	(hp)
Number of Engines	2	
Blend Deck Specifications [1]		
Blender Engine #1 Size	850	(hp)
Number of Engines	1	
Blender Engine #2 Size	600	(hp)
Number of Engines	1	
Fuel Consumption [2]	7,000	(Btu/bhp-hr)
Main Frac Pump [3]	6.86	(MMBtu/hr)
Pump Down [3]	9.27	(MMBtu/hr)
Blend Engine #1 [3]	5.95	(MMBtu/hr)
Blend Engine #2 [3]	4.20	(MMBtu/hr)
Number of Stages [1]	40	(stages/well)
Main Frac Pump Operating Hours [1]	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Pump Down Operating Hours [1]	0.33	(hr/engine-stage)
	13	(hr/engine-well)
Blend Engine Operating Hours	1.5	(hr/engine-stage)
	60	(hr/engine-well)
Fuel Heating Value [4]	137,000	(Btu/gal)
Sulfur Content [5]	15	(ppmw)
Fuel Density	6.8	(lb/gal)

[12] Speciated pollutants are for modeling purposes only. Speciations are based on the National Park Service (NPS) "Particulate Matter Speciation" web page for oil-fired combustion turbines. The following speciations apply:
Filterable PM is 37% of total PM;
Condensible PM is 63% of total PM;
Elemental Carbon (EC) is 50% of filterable PM;
Soils are 50% of filterable PM;
Sulfates (SO_4) are 40% of SO_2 and adjusted for differences in molecular weights (multiplied by lb-mol for SO_4/SO_2 = 96/64); and, Organic Carbon (OC) is the difference of sulfates (SO_4) and condensible PM.

Table A-4 Emissions Summary from Engines for Drilling, Completion and Fracturing (per well)

Activity	Tier 2 Compliant Rigs															
	Criteria Pollutants						Hazardous Air Pollutants						Greenhouse Gases			
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	Formaldehyde	n-Hexane	CO_2	CH_4	N_2O	CO_2e
	(tons)															
Drill Rig	2.77	1.58	2.87E-03	9.13E-02	9.13E-02	0.15	7.90E-03	5.52E-03	1.38E-03	5.55E-03	4.26E-02	7.90E-04	315.0	1.28E-02	2.56E-03	316.1
Completions Rig	0.16	9.03E-02	1.64E-04	5.21E-03	5.21E-03	8.33E-03	4.51E-04	3.15E-04	7.87E-05	3.17E-04	2.43E-03	4.51E-05	18.0	7.29E-04	1.46E-04	18.0
Hydraulic Fracturing	5.97	3.40	6.18E-03	1.96E-01	1.96E-01	0.31	1.70E-02	1.19E-02	2.96E-03	1.19E-02	9.17E-02	1.70E-03	677.4	2.71E-02	5.41E-03	679.7
Total	**8.90**	**5.07**	**9.22E-03**	**0.29**	**0.29**	**0.47**	**2.53E-02**	**1.77E-02**	**4.42E-03**	**1.78E-02**	**0.14**	**2.53E-03**	**1,010**	**4.1E-02**	**8.1E-03**	**1,014**

Activity	Tier 4 Compliant Rigs															
	Criteria Pollutants						Hazardous Air Pollutants						Greenhouse Gases			
	NO_x	CO	SO_2	PM_{10}	$PM_{2.5}$	VOC	Benzene	Toluene	Ethylbenzene	Xylene	Formaldehyde	n-Hexane	CO_2	CH_4	N_2O	CO_2e
	(tons)															
Drill Rig	1.58	1.58	2.87E-03	1.83E-02	1.83E-02	8.52E-02	4.61E-03	3.22E-03	8.04E-04	3.24E-03	2.49E-02	4.61E-04	315.0	1.28E-02	2.56E-03	316.1
Completions Rig	0.02	9.03E-02	1.64E-04	7.64E-04	7.64E-04	4.86E-03	2.63E-04	1.84E-04	4.59E-05	1.85E-04	1.42E-03	2.63E-05	18.0	7.29E-04	1.46E-04	18.0
Hydraulic Fracturing	3.40	3.40	6.18E-03	3.93E-02	3.93E-02	0.18	9.91E-03	6.92E-03	1.73E-03	6.96E-03	5.35E-02	9.91E-04	677.4	2.71E-02	5.41E-03	679.7
Total	**5.00**	**5.07**	**9.22E-03**	**5.83E-02**	**5.83E-02**	**0.27**	**1.48E-02**	**1.03E-02**	**2.58E-03**	**1.04E-02**	**7.98E-02**	**1.48E-03**	**1,010**	**4.1E-02**	**8.1E-03**	**1,014**

Table A-5 Emissions Calculations from Construction

Well Pads [2]	11	(pads/yr)
Facility Pads [2]	7	(pads/yr)
Roads [2]	4	(miles/yr)

Table A-5a Particulate Emissions for Well and Facility Pads from Construction

Disturbance Type	Size [2]	TSP Emission Factor [3]		Peak Disturbance	Per-Pad Duration [4]			Control Efficiency [5]	Particulate Emissions (Controlled)					
									TSP		PM_{10} [6]		$PM_{2.5}$ [7]	
	(acres/pad)			(acres/yr)	(days/acre)	(hours/day)	(hours)	(%)	(lb/hr)	(tpy)	(lb/hr)	(tpy)	(lb/hr)	(tpy)
Well Pads	3.90	1.2	ton/acre-month	42.9	5	12	234	50	6.4	8.3	2.3	3.0	0.61	0.78
Facility Pads	8.03	1.2	ton/acre-month	56.2	5	12	482	50	13.2	22.3	4.8	8.0	1.3	2.1

Table A-5b Particulate Emissions for Roads and ROW from Construction

Disturbance Type	Size [2]	TSP Emission Factor [3]		Peak Disturbance	Duration [4]			Control Efficiency [5]	Particulate Emissions (Controlled)					
									TSP		PM_{10} [6]		$PM_{2.5}$ [7]	
	(acres/mile)			(acres/yr)	(days/acre)	(hours/day)	(hours/yr)	(%)	(lb/hr)	(tpy)	(lb/hr)	(tpy)	(lb/hr)	(tpy)
Roads and ROW	12.36	1.2	ton/acre-month	49.4	5	12	60	50	20.3	2.4	7.3	0.88	1.9	0.23

Footnotes:

[1] Note: there are no GHG emissions for this source since there are no combustion activities.

[2] Based on proposed surface disturbance in plan of development.

[3] TSP emission factors based on AP-42, Section 13.2.3, "Heavy Construction Operations", Sub-Section 12.2.3.3, "Emission Factors".

[4] Estimated duration.

[5] Assumed control efficiency for watering.

[6] PM_{10} emissions size range based on AP-42 Section 13.2.2, "Unpaved Roads", Background Documention, September 1998. Assuming that 36% of the TSP is in the PM_{10} size range, monthly emissions converted to daily and hourly emissions based on 30-day month.

[7] $PM_{2.5}$ emissions size range based on AP-42 Section 13.2.2, "Unpaved Roads", Background Documention, September 1998. Assuming that 9.5% of the TSP is in the $PM_{2.5}$ size range, monthly emissions converted to daily and hourly emissions based on 30-day month.

Table A-6 Emissions Calculations from Gas-fired Separator Heaters

Annual Operating Hours [1]	11,677	
Heat Content [2]	1,306	(Btu/scf)
Fuel Sulfur Content [3]	0.003	(gr/scf)
Design Firing Rate [2]	4.000	(MMBtu/hr)
	4.71E-03	(MMscf/hr)

Table A-6a Criteria Pollutant and HAP Emissions for Gas Fired Separator Heaters

Pollutant		Emission Factor [4]	Emission Rate	
		(lb/MMscf)	(lb/hr)	(tpy)
Criteria Pollutant	NO_x	128.0	0.60	3.5
	CO	107.6	0.51	3.0
	SO_2 [5]	8.44E-04	3.98E-06	2.32E-05
	Total PM	7.6	0.04	0.21
	VOC	5.5	0.03	0.15
HAP	Benzene	2.10E-03	9.90E-06	5.78E-05
	Toluene	3.40E-03	1.60E-05	9.35E-05
	Ethylbenzene	ND	ND	ND
	Xylene	ND	ND	ND
	Formaldehyde	0.08	3.53E-04	2.06E-03
	n-Hexane	1.80	8.48E-03	0.05

Table A-6b GHG Emissions for Gas Fired Separator (Heater Treater)

Pollutant		Emission Factor [6]	Emission Rate	
		(kg/MMBtu)	(lb/hr)	(tpy)
GHG [6]	CO_2	59	520.3	2,278.9
	CH_4	3.00E-03	0.03	0.12
	N_2O	6.00E-04	5.29E-03	0.02
	CO_2e	--	--	2,289

Table A-6c Speciated PM Emissions for Gas Fired Separator (Heater Treater)

Speciated Pollutant [7]		Emission Rate	
		(lb/hr)	(tpy)
Speciated	Filterable PM	8.95E-03	0.05
	Condensible PM	0.03	0.16
	Elemental Carbon (EC)	0.01	0.05
	Soils	--	--
	Sulfate (SO_4)	1.99E-06	1.16E-05
	Organic Carbon (OC)	0.03	0.16

Footnotes:

[1] Annual operating hours based on 8,760 hours per year, plus each heater has a companion heater that operates during the winter (assume 4 months out of 12 per year).

[2] Design firing rate. Heat content based on fuel gas analysis provided in Appendix ??.

[3] Fuel sulfur content based on specifications.

[4] Emission factors based on AP-42 Section 1.4, "Natural Gas Combustion". NOx and CO emission factors are based on Table 1.4-1 for "Small Boilers". VOC, SO_2, PM_{10}, and $PM_{2.5}$ emission factors are based on Table 1.4-2. HAP emission factors are based on Table 1.4-3. "ND" refers to "Not Detected".

[5] SO_2 emission factor is converted to a different natural gas sulfur content by multiplying the SO_2 emission factor in Table 1.4-2 by the ratio of the site-specific sulfur content (grains/10^6 scf) to 2,000 grains/10^6 scf. Example calculation: emission factor (lb/MMscf) = fuel sulfur content (gr/Mscf) / 7,000 gr/lb x (Mscf/MMscf) x (64 lb/lb-mol SO_2/32 lb/lb-mol S) x 1,000

Table A-6 Emissions Calculations from Gas-fired Separator Heaters

Annual Operating Hours [1]	11,677	
Heat Content [2]	1,306	(Btu/scf)
Fuel Sulfur Content [3]	0.003	(gr/scf)
Design Firing Rate [2]	4.000	(MMBtu/hr)
	4.71E-03	(MMscf/hr)

[6] GHG emission factors are based on the following sources: 40 CFR Part 98, Table C-1 for CO_2 and Table C-2 for CH_4 and N_2O (both for fuel gas). CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[7] Speciated pollutants are for modeling purposes only. Speciations are based on the National Park Service (NPS) "Particulate Matter Speciation" web page for natural gas fired combustion turbines. The following speciations apply:
Filterable PM is 25% of total PM;
Condensible PM is 75% of total PM;
Elemental Carbon (EC) is 100% of filterable PM;
Soils are not applicable for natural gas fired combustion engines;
Sulfates (SO_4) are 33.3% (1/3) of SO_2 and adjusted for differences in molecular weights (multiplied by lb-mol for SO_4/SO_2 = 96/64); and, Organic Carbon (OC) is the difference of sulfates (SO_4) and condensible PM.

Table A-7 Emissions Calculations from VOC Flashing at Tank Batteries

Oil Flash Gas-Oil Ratio [1]	76	(scf/bbl)
Water Flash Gas-Oil Ratio [1]	0.16	(scf/bbl)
Oil Flash Gas Molecular Weight [1]	45.54	(lb/lbmol)
Water Flash Gas Molecular Weight [1]	24.05	(lb/lbmol)
Operating Time	8,760	(hrs/yr)

Table A-7a Criteria Pollutant, HAP, and GHG Emissions for Tank Battery Flash

Pollutant		Reduction Efficiency [2]	Emission Rate							
			Oil Tanks				Water Tanks			
			Pre-VRU		Post-VRU		Pre-VRU		Post-VRU	
		(%)	(lb/hr/bpd)	(tpy/bpd)	(lb/hr/bpd)	(tpy/bpd)	(lb/hr/bpd)	(tpy/bpd)	(lb/hr/bpd)	(tpy/bpd)
Criteria Pollutant	VOC	99.5	0.31	1.36	1.55E-03	6.80E-03	1.15E-04	5.05E-04	5.76E-07	2.52E-06
HAP	Benzene	99.5	2.40E-04	1.05E-03	1.20E-06	5.25E-06	3.45E-06	1.51E-05	1.72E-08	7.55E-08
	Toluene	99.5	3.54E-04	1.55E-03	1.77E-06	7.75E-06	3.36E-06	1.47E-05	1.68E-08	7.36E-08
	Ethylbenzene	99.5	3.42E-05	1.50E-04	1.71E-07	7.50E-07	1.31E-07	5.74E-07	6.56E-10	2.87E-09
	Xylenes	99.5	1.94E-04	8.50E-04	9.70E-07	4.25E-06	1.79E-06	7.82E-06	8.93E-09	3.91E-08
	n-Hexane	99.5	6.29E-03	2.75E-02	3.14E-05	1.38E-04	1.24E-06	5.43E-06	6.20E-09	2.71E-08
GHG [3]	CO_2	99.5	1.10E-04	4.83E-04	5.52E-07	2.42E-06	3.52E-06	1.54E-05	1.76E-08	7.72E-08
	CH_4	99.5	9.51E-03	0.04	4.75E-05	2.08E-04	1.77E-04	7.74E-04	8.84E-07	3.87E-06
	CO_2e	99.5	--	1.0	--	5.21E-03	--	0.02	--	9.69E-05

Table A-7b Flash Gas Analysis Composition

No.	Component	Composition [4]			
		Oil Flash		Water Flash	
		Mol%	Wt %	Mol%	Wt %
1	H2S	0.000	0.000	0.000	0.000
2	O2	0.000	0.000	0.000	0.000
3	CO2	0.030	0.029	0.455	0.833
4	N2	0.000	0.000	8.825	10.28
5	Methane	7.082	2.499	62.63	41.79
6	Ethane	24.05	15.88	15.89	19.87
7	Propane	36.45	35.30	7.677	14.06
8	Isobutane	6.526	8.329	0.652	1.575
9	n-Butane	15.40	19.65	1.931	4.668
10	2,2 Dimethylpropane	0.057	0.090	0.007	0.022
11	Isopentane	3.097	4.907	0.299	0.898
12	n-Pentane	3.310	5.244	0.336	1.008
13	2,2 Dimethylbutane	0.033	0.062	0.000	0.000
14	Cyclopentane	0.000	0.000	0.000	0.000
15	2,3 Dimethylbutane	0.181	0.343	0.066	0.236
16	2 Methylpentane	0.589	1.115	0.053	0.189
17	3 Methylpentane	0.304	0.575	0.036	0.127
18	n-Hexane	0.873	1.652	0.082	0.293
19	Methylcyclopentane	0.305	0.564	0.088	0.31
20	Benzene	0.037	0.063	0.251	0.815
21	Cyclohexane	0.306	0.565	0.119	0.418
22	2-Methylhexane	0.089	0.196	0.011	0.046
23	3-Methylhexane	0.097	0.213	0.015	0.061
24	2,2,4 Trimethylpentane	0.000	0.000	0.000	0.000
25	Other C7's	0.258	0.562	0.046	0.189
26	n-Heptane	0.205	0.451	0.031	0.129
27	Methylcyclohexane	0.270	0.582	0.076	0.31
28	Toluene	0.046	0.093	0.207	0.794
29	Other C8's	0.22	0.532	0.026	0.121
30	n-Octane	0.061	0.153	0.023	0.11

Table A-7 Emissions Calculations from VOC Flashing at Tank Batteries

Oil Flash Gas-Oil Ratio [1]	76	(scf/bbl)
Water Flash Gas-Oil Ratio [1]	0.16	(scf/bbl)
Oil Flash Gas Molecular Weight [1]	45.54	(lb/lbmol)
Water Flash Gas Molecular Weight [1]	24.05	(lb/lbmol)
Operating Time	8,760	(hrs/yr)

31	Ethylbenzene	0.004	0.009	0.007	0.031
32	m&p Xylenes	0.018	0.042	0.076	0.335
33	o Xylene	0.004	0.009	0.02	0.087
34	Other C9's	0.072	0.200	0.016	0.086
35	n-Nonane	0.003	0.008	0.017	0.092
36	Other C10's	0.023	0.071	0.024	0.142
37	n-Decane	0.001	0.003	0.014	0.082
38	Undecanes (11)	0.004	0.013	0.000	0.000

Footnotes:

[1] Flash gas-oil ratios and molecular weights based on gas sample. Gas oil ratio based on "Stock Tank" value listed under "Job Number: J61194". Gas water ratio based on "Stock Tank" value listed under "Job Number: J61194".

[2] NMED allows 100% VRU reduction with a redundant VRU but 99.5% is used to be conservative.

[3] GHG emissions are based on the flash gas-oil ratios and the weight percent of the flash gas analysis composition. CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[4] Composition based on Chromatograph Extended Analysis - GPA 2286, Job Number: 61194.011 for oil flash and Job Number: 61194.021 for water flash.

Table A-8 Emissions Calculations from Working and Breathing Losses from Oil Tanks at Tank Batteries

Tank Volume [1]	1,000	(bbl)
Tank Throughput [1]	1,720	(bbl/day)
Tank Color [1]	Gray	
Vapor Molecular Weight [1]	53.82	(lb/lbmol)
Max Ambient Temperature [1]	77	(F)
Min Ambient Temperature [1]	49.9	(F)
Tank Paint Factor [1]	0.54	(α)
Solar Insulation Factor [1]	1,802	(Btu/ft^2*day)
Solar Paint Adsorptance [1]	0.54	(dimensionless)

Table A-8a Criteria Pollutant, HAP, and GHG Emissions for Tank Battery Oil Working/Breathing Losses

Pollutant		Reduction Efficiency [2]	Emission Rate			
			Pre-VRU		Post-VRU	
		(%)	(lb/hr/tank)	(tpy/tank)	(lb/hr/tank)	(tpy/tank)
Criteria Pollutant	VOC	99.5	38.9	170.3	0.19	0.85
HAP	Benzene	99.5	0.04	0.16	1.79E-04	7.82E-04
	Toluene	99.5	0.04	0.16	1.81E-04	7.91E-04
	Ethylbenzene	99.5	1.66E-03	7.28E-03	8.31E-06	3.64E-05
	Xylenes	99.5	0.92	4.01	4.58E-03	2.00E-02
	n-Hexane	99.5	1.0	4.5	5.15E-03	2.25E-02
GHG [3]	CO_2	99.5	3.74E-03	0.02	1.87E-05	8.19E-05
	CH_4	99.5	0.17	0.76	8.72E-04	3.82E-03
	CO_2e	99.5	--	19.1	--	0.10

Table A-8 Emissions Calculations from Working and Breathing Losses from Oil Tanks at Tank Batteries

Tank Volume [1]	1,000	(bbl)
Tank Throughput [1]	1,720	(bbl/day)
Tank Color [1]	Gray	
Vapor Molecular Weight [1]	53.82	(lb/lbmol)
Max Ambient Temperature [1]	77	(F)
Min Ambient Temperature [1]	49.9	(F)
Tank Paint Factor [1]	0.54	(α)
Solar Insulation Factor [1]	1,802	(Btu/ft^2*day)
Solar Paint Adsorptance [1]	0.54	(dimensionless)

Table A-8b Flash Gas Analysis Composition

No.	Component	Composition [4]	
		Oil Flash	
		Mol%	Wt %
1	H2S	0.000	0.000
2	O2	0.000	0.000
3	CO2	0.011	0.009
4	N2	0.000	0.000
5	Methane	1.411	0.420
6	Ethane	10.702	5.979
7	Propane	34.542	28.299
8	Isobutane	8.903	9.614
9	n-Butane	24.356	26.301
10	2,2 Dimethylpropane	0.094	0.126
11	Isopentane	6.043	8.100
12	n-Pentane	6.741	9.036
13	2,2 Dimethylbutane	0.066	0.106
14	Cyclopentane	0.000	0.000
15	2,3 Dimethylbutane	0.362	0.580
16	2 Methylpentane	1.204	1.928
17	3 Methylpentane	0.618	0.989
18	n-Hexane	1.548	2.478
19	Methylcyclopentane	0.597	0.934
20	Benzene	0.059	0.086
21	Cyclohexane	0.587	0.917
22	2-Methylhexane	0.170	0.316
23	3-Methylhexane	0.181	0.337
24	2,2,4 Trimethylpentane	0.000	0.000
25	Other C7's	0.484	0.892
26	n-Heptane	0.356	0.663
27	Methylcyclohexane	0.443	0.808
28	Toluene	0.051	0.087
29	Other C8's	0.314	0.643
30	n-Octane	0.064	0.136
31	Ethylbenzene	0.002	0.004
32	m&p Xylenes	0.011	0.022
33	o Xylene	0.002	0.004
34	Other C9's	0.064	0.150
35	n-Nonane	0.007	0.017
36	Other C10's	0.004	0.010
37	n-Decane	0.001	0.003
38	Undecanes (11)	0.002	0.006

Ambient Data [1]

Atmospheric pressure (Pa) [5]	13.1	(psia)
Max Ambient Temp (Tax)	77	(F)
Min Ambient Temp (Tan)	49.9	(F)
Daily Average Amb. Temp (Taa)	523.1	(R)
Daily Ambient Temp Range (ΔTa)	27.1	(F)
Tank paint factor (alpha)	0.54	(α)
Solar Insolation Factor (I)	1,802	(Btu/ft^2*day)
Daily vapor temp. range (ΔTv) [6]	46.8	(R)
Liquid Bulk Temp (Tb) [7]	525.4	(R)
Daily Avg Liq surf temp (Tla) [8]	532.1	(R)
Daily Max Liq surf temp (Tlx) [9]	543.8	(R)
Daily Min Liq surf temp (Tln) [10]	520.4	(R)

Annual Emissions - Actual

Material	Oil	
Vapor Molecular Weight	53.8	(lb/lbmol)
Annual net throughput (Q)	627,800	(bbl/yr)
Tank Capacity [11]	1,008	(bbl)
Turnover per year (N) [12]	622.7	
Turnover factor (Kn)	1	
Working loss product factor (Kp)	0.75	
Color	Gray	
Solar Paint Absorptance	0.54	
Tank Shell Height (Hs)	30	(ft)
Liquid Height (Hl) [13]	15	(ft)
Diameter	15.5	(ft)
Roof Outage (Hro)	0	(ft)
Vapor Space Outage (Hvo) [14]	15	(ft)
Vapor Space Volume (Vv) [15]	2,830	(ft^3)
Vapor Density (Wv) [16]	0.14	(lb/ft^3)
VP @daily max liq surf temp (Pvx)	14.45	(psia)
VP @daily min liq surf temp (Pvn)	14.24	(psia)
Daily Vapor Pressure Range (ΔPv)	0.21	(psia)
VP at daily avg liq surf temp (Pva)	14.34	(psia)
Breather Vent Pressure Setting Range (ΔPb)	0.06	(psia)
Vapor Space Expansion Factor (Ke) [17]	0.03	
Vented Vapor Saturation factor (Ks) [18]	0.08	
Standing Storage Loss (Ls) [19]	368	(lb/yr)
Working Loss (Lw) [20]	363,468	(lb/yr)
Total Losses (Lt) [21]	363,836	(lb/yr)
Total Losses (Lt) [21]	181.9	(tpy)

Table A-8 Emissions Calculations from Working and Breathing Losses from Oil Tanks at Tank Batteries

Tank Volume [1]	1,000	(bbl)
Tank Throughput [1]	1,720	(bbl/day)
Tank Color [1]	Gray	
Vapor Molecular Weight [1]	53.82	(lb/lbmol)
Max Ambient Temperature [1]	77	(F)
Min Ambient Temperature [1]	49.9	(F)
Tank Paint Factor [1]	0.54	(α)
Solar Insulation Factor [1]	1,802	(Btu/ft^2*day)
Solar Paint Adsorptance [1]	0.54	(dimensionless)

Footnotes:

[1] Tank parameters and ambient data based on plan of development.

[2] NMED allows 100% VRU reduction with a redundant VRU but using 99.5% to be conservative.

[3] GHG emissions are based on the weight percent of the flash gas analysis composition and total losses. CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[4] Composition based on Chromatograph Extended Analysis - GPA 2286, Job Number: 61194.071 for oil flash.

[5] Atmospheric pressure based on the following equation accounting for an average elevation of 3,200 feet (975.36 m) at the Hayhurst Development Area: P = 101,325 * (1 - 2.25577*10^-5 * h)^5.25588, where "P" is the air pressure in Pascals and "h" is the altitude above sea level in meters. Equation derived from "The Engineering Toolbox" website. 1 Pascal = 0.000145038 psia.

[6] Daily vapor temperature range based AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-8.
Example calculation: daily vapor temperature range (ΔTv) = [0.72 x daily ambient temperature range (ΔTa)] + [0.028 x tank paint factor (α) x solar insulation factor (I)]

[7] Liquid bulk temperature based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-28.
Example calculation: liquid bulk temperature (Tb) = daily average ambient temperature (Taa) + [6 x tank paint factor (α) -1]

[8] Daily average liquid surface temperature based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", sub-section 6 on page 7.1-109.
Example calculation: daily average liquid surface temperature (Tla) = [0.44 x daily average ambient temperature (Taa)] +[0.56 x liquid bulk temperature (Tb)] + [0.0079 x tank paint factor (α) x solar insulation factor (I)]

[9] Daily maximum liquid surface temperature based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Figure 7.1-17.
Example calculation: daily maximum liquid surface temperature (Tlx) = daily average liquid surface temperature (Tla) + 0.25 x daily vapor temperature range (ΔTv)

[10] Daily minimum liquid surface temperature based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Figure 7.1-17.
Example calculation: daily minimum liquid surface temperature (Tln) = daily average liquid surface temperature (Tla) - 0.25 x daily vapor temperature range (ΔTv)

[11] Tank capacity based on the following equation: pi x diameter^2 x tank shell height (Hs) x 7.48 gal/cubic foot x 1/42 bbl/gal x1/4

[12] Turnovers based on annual net throughput (Q) divided by tank capacity.

[13] Liquid height assumed to be half the tank shell height.

[14] Vapor space outage based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-15.
Example calculation: vapor space outage (Hvo) = tank shell height (Hs) - liquid height (Hl) + roof outage (Hro)

[15] Vapor space volume based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-3.
Example calculation: vapor space volume (Vv) = pi/4 x diameter^2 x vapor space outage (Hvo)

[16] Vapor density based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-21.
Example calculation: vapor density (Wv) = vapor molecular weight x vapor pressure at daily average liquid surface temperature (Pva) / R x daily average liquid surface temperature (Tla), where R = ideal gas constant = 10.731

[17] Vapor space expansion factor based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-7.
Example calculation: vapor space expansion factor (Ke) = [daily vapor temperature range (ΔTv) / daily average liquid surface temperature (Tla)] + [(daily vapor pressure range (ΔPv) - breather vent pressure setting range (ΔPb)) / (atmospheric pressure (Pa) - vapor pressure at daily average

[18] Vented vapor saturation factor based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-20.
Example calculation: vented vapor saturation factor (Ks) = 1 / [1 + 0.053 x vapor pressure at daily average liquid surface temperature (Pva) x vapor space outage (Hvo)]

[19] Standing storage loss based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-2.
Example calculation: standing storage loss (Ls) = 365 x vapor density (Wv) x vapor space volume (Vv) x vapor space expansion factor (Ke) x vented vapor saturation factor (Ks)

[20] Working loss based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-29.
Example calculation: working loss (Lw) = 0.001 x molecular weight x vapor pressure at daily average liquid surface temperature (Pva) x annual net throughput (Q) x turnover factor (Kn) x working loss product factor (Kp)

[21] Total losses based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-1.
Example calculation: total loss (Lt) = standing storage loss (Ls) + working loss (Lw)

Table A-9 Emissions Calculations from Working and Breathing Losses from Water Tanks at Tank Batteries

Tank Volume [1]	1,000	(bbl)
Tank Throughput [1]	1,720	(bbl/day)
Tank Color [1]	Gray	
Vapor Molecular Weight [1]	53.82	(lb/lbmol)
Max Ambient Temperature [1]	77	(F)
Min Ambient Temperature [1]	49.9	(F)
Tank Paint Factor [1]	0.54	(α)
Solar Insulation Factor [1]	1,802	(Btu/ft^2*day)
Solar Paint Adsorptance [1]	0.54	(dimensionless)

Table A-9a Criteria Pollutant, HAP, and GHG Emissions for Tank Battery Water Working/Breathing Losses

Pollutant		Reduction Efficiency [2]	Emission Rate			
			Pre-VRU		Post-VRU	
		(%)	(lb/hr/tank)	(tpy/tank)	(lb/hr/tank)	(tpy/tank)
Criteria Pollutant	VOC	99.5	2.0	8.7	9.91E-03	0.04
HAP	Benzene	99.5	1.82E-03	7.97E-03	9.10E-06	3.99E-05
	Toluene	99.5	1.84E-03	8.07E-03	9.21E-06	4.03E-05
	Ethylbenzene	99.5	8.47E-05	3.71E-04	4.23E-07	1.85E-06
	Xylenes	99.5	5.50E-04	2.41E-03	2.75E-06	1.21E-05
	n-Hexane	99.5	0.05	0.23	2.62E-04	1.15E-03
GHG [3]	CO_2	99.5	3.65E-03	8.34E-04	1.83E-05	4.17E-06
	CH_4	99.5	0.17	0.04	8.53E-04	1.95E-04
	CO_2e	--	--	0.97	--	4.87E-03

Table A-9 Emissions Calculations from Working and Breathing Losses from Water Tanks at Tank Batteries

Tank Volume [1]	1,000	(bbl)
Tank Throughput [1]	1,720	(bbl/day)
Tank Color [1]	Gray	
Vapor Molecular Weight [1]	53.82	(lb/lbmol)
Max Ambient Temperature [1]	77	(F)
Min Ambient Temperature [1]	49.9	(F)
Tank Paint Factor [1]	0.54	(α)
Solar Insulation Factor [1]	1,802	(Btu/ft^2*day)
Solar Paint Adsorptance [1]	0.54	(dimensionless)

Table A-9b Flash Gas Analysis Composition

No.	Component	Composition [4]	
		Oil Flash [5]	
		Mol%	Wt %
1	H2S	0.000	0.000
2	O2	0.000	0.000
3	CO2	0.011	0.009
4	N2	0.000	0.000
5	Methane	1.411	0.420
6	Ethane	10.702	5.979
7	Propane	34.542	28.299
8	Isobutane	8.903	9.614
9	n-Butane	24.356	26.301
10	2,2 Dimethylpropane	0.094	0.126
11	Isopentane	6.043	8.100
12	n-Pentane	6.741	9.036
13	2,2 Dimethylbutane	0.066	0.106
14	Cyclopentane	0.000	0.000
15	2,3 Dimethylbutane	0.362	0.580
16	2 Methylpentane	1.204	1.928
17	3 Methylpentane	0.618	0.989
18	n-Hexane	1.548	2.478
19	Methylcyclopentane	0.597	0.934
20	Benzene	0.059	0.086
21	Cyclohexane	0.587	0.917
22	2-Methylhexane	0.170	0.316
23	3-Methylhexane	0.181	0.337
24	2,2,4 Trimethylpentane	0.000	0.000
25	Other C7's	0.484	0.892
26	n-Heptane	0.356	0.663
27	Methylcyclohexane	0.443	0.808
28	Toluene	0.051	0.087
29	Other C8's	0.314	0.643
30	n-Octane	0.064	0.136
31	Ethylbenzene	0.002	0.004
32	m&p Xylenes	0.011	0.022
33	o Xylene	0.002	0.004
34	Other C9's	0.064	0.150
35	n-Nonane	0.007	0.017
36	Other C10's	0.004	0.010
37	n-Decane	0.001	0.003
38	Undecanes (11)	0.002	0.006

Ambient Data

Atmospheric pressure (Pa) [6]	13.1	(psia)
Max Ambient Temp (Tax)	77	(F)
Min Ambient Temp (Tan)	49.9	(F)
Daily Average Amb. Temp (Taa)	523.1	(R)
Daily Ambient Temp Range (ΔTa)	27.1	(F)
Tank paint factor (alpha)	0.54	(α)
Solar Insolation Factor (I)	1,802	(Btu/ft^2*da
Daily vapor temp. range (ΔTv) [7]	46.8	(R)
Liquid Bulk Temp (Tb) [8]	525.4	(R)
Daily Avg Liq surf temp (Tla) [9]	532.1	(R)
Daily Max Liq surf temp (Tlx) [10]	543.8	(R)
Daily Min Liq surf temp (Tln) [11]	520.4	(R)

Annual Emissions - Actual

Material	Water	
Vapor Molecular Weight	53.8	(lb/lbmol)
Annual net throughput (Q) [5]	31,390	(BBL/yr)
Tank Capacity [12]	1,008	(BBL)
Turnover per year (N) [13]	31.1	
Turnover factor (Kn)	1	
Working loss product factor (Kp)	0.75	
Color	Gray	
Solar Paint Absorptance	0.54	
Tank Shell Height (Hs)	30	(ft)
Liquid Height (Hl) [14]	15	(ft)
Diameter	15.5	(ft)
Roof Outage (Hro)	0	(ft)
Vapor Space Outage (Hvo) [15]	15	(ft)
Vapor Space Volume (Vv) [16]	2,830	(ft^3)
Vapor Density (Wv) [17]	0.14	(lb/ft^3)
VP @daily max liq surf temp (Pvx)	14.45	(psia)
VP @daily min liq surf temp (Pvn)	14.24	(psia)
Daily Vapor Pressure Range (ΔPv)	0.21	(psia)
VP at daily avg liq surf temp (Pva)	14.34	(psia)
Breather Vent Pressure Setting Range (ΔPb)	0.06	(psia)
Vapor Space Expansion Factor (Ke) [18]	0.03	
Vented Vapor Saturation factor (Ks) [19]	0.08	
Standing Storage Loss (Ls) [20]	368	(lb/yr)
Working Loss (Lw) [21]	18,173	(lb/yr)
Total Losses (Lt) [22]	18,542	(lb/yr)
Total Losses (Lt) [22]	9.3	(tpy)

Table A-9 Emissions Calculations from Working and Breathing Losses from Water Tanks at Tank Batteries

Tank Volume [1]	1,000	(bbl)
Tank Throughput [1]	1,720	(bbl/day)
Tank Color [1]	Gray	
Vapor Molecular Weight [1]	53.82	(lb/lbmol)
Max Ambient Temperature [1]	77	(F)
Min Ambient Temperature [1]	49.9	(F)
Tank Paint Factor [1]	0.54	(α)
Solar Insulation Factor [1]	1,802	(Btu/ft^2*day)
Solar Paint Adsorptance [1]	0.54	(dimensionless)

Footnotes:

[1] Tank parameters and ambient data based on plan of development.

[2] NMED allows 100% VRU reduction with a redundant VRU but using 99.5% to be conservative.

[3] GHG emissions are based on the weight percent of the flash gas analysis composition and total losses. CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[4] Composition based on Chromatograph Extended Analysis - GPA 2286, Job Number: 61194.071 for oil flash

[5] Assume 5% oil carry-over into water tanks.

[6] Atmospheric pressure based on the following equation accounting for an average elevation of 3,200 feet (975.36 m) at the Hayhurst Development Area: P = 101,325 * (1 - 2.25577*10^-5 * h)^5.25588, where "P" is the air pressure in Pascals and "h" is the altitude above sea level in meters. Equation derived from "The Engineering Toolbox" website. 1 Pascal = 0.000145038 psia.

[7] Daily vapor temperature range based AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-8
Example calculation: daily vapor temperature range (ΔTv) = [0.72 x daily ambient temperature range (ΔTa)] + [0.028 x tank paint factor (α) x solar insulation factor (I)]

[8] Liquid bulk temperature based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-28.
Example calculation: liquid bulk temperature (Tb) = daily average ambient temperature (Taa) + [6 x tank paint factor (α) -1]

[9] Daily average liquid surface temperature based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", sub-section 6 on page 7.1-109
Example calculation: daily average liquid surface temperature (Tla) = [0.44 x daily average ambient temperature (Taa)] +[0.56 x liquid bulk temperature (Tb)] + [0.0079 x tank paint factor (α) x solar insulation factor (I)]

[10] Daily maximum liquid surface temperature based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Figure 7.1-17
Example calculation: daily maximum liquid surface temperature (Tlx) = daily average liquid surface temperature (Tla) + 0.25 x daily vapor temperature range (ΔTv)

[11] Daily minimum liquid surface temperature based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Figure 7.1-17
Example calculation: daily minimum liquid surface temperature (Tln) = daily average liquid surface temperature (Tla) - 0.25 x daily vapor temperature range (ΔTv)

[12] Tank capacity based on the following equation: pi x diameter^2 x tank shell height (Hs) x 7.48 gal/cubic foot x 1/42 bbl/gal x1/4

[13] Turnovers based on annual net throughput (Q) divided by tank capacity.

[14] Liquid height assumed to be half the tank shell height.

[15] Vapor space outage based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-15.
Example calculation: vapor space outage (Hvo) = tank shell height (Hs) - liquid height (Hl) + roof outage (Hro)

[16] Vapor space volume based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-3.
Example calculation: vapor space volume (Vv) = pi/4 x diameter^2 x vapor space outage (Hvo)

[17] Vapor density based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-21.
Example calculation: vapor density (Wv) = vapor molecular weight x vapor pressure at daily average liquid surface temperature (Pva) / R x daily average liquid surface temperature (Tla), where R = ideal gas constant = 10.731

[18] Vapor space expansion factor based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-7.
Example calculation: vapor space expansion factor (Ke) = [daily vapor temperature range (ΔTv) / daily average liquid surface temperature (Tla)] + [(daily vapor pressure range (ΔPv) - breather vent pressure setting range (ΔPb)) / (atmospheric pressure (Pa) - vapor pressure at daily average liquid surface temperature

[19] Vented vapor saturation factor based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-20.
Example calculation: vented vapor saturation factor (Ks) = 1 / [1 + 0.053 x vapor pressure at daily average liquid surface temperature (Pva) x vapor space outage (Hvo)]

[20] Standing storage loss based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-2.
Example calculation: standing storage loss (Ls) = 365 x vapor density (Wv) x vapor space volume (Vv) x vapor space expansion factor (Ke) x vented vapor saturation factor (Ks)

[21] Working loss based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-29.
Example calculation: working loss (Lw) = 0.001 x molecular weight x vapor pressure at daily average liquid surface temperature (Pva) x annual net throughput (Q) x turnover factor (Kn) x working loss product factor (Kp)

[22] Total losses based on AP-42 Section 7.1, "Organic Liquid Storage Tanks", Equation 1-1.
Example calculation: total loss (Lt) = standing storage loss (Ls) + working loss (Lw)

Table A-10 Emissions Calculations from Tank Batteries

Table 10-1 Component Count for Oil Production (Western US) [1]

Major Equipment	Valves	Flanges	Connectors	Open-ended Lines	Other Components [2]
Wellhead	5	10	4	0	1
Separator	6	12	10	0	0
Meters/piping	0	0	0	0	0
Heater-Treater	8	12	20	0	0
Header	5	10	4	0	0
In-line Heaters	0	0	0	0	0
Dehydrators	0	0	0	0	0
Compressors	0	0	0	0	0

Table 10-2 Component Count for Gas Production (Western US) [1]

Major Equipment	Valves	Flanges	Connectors	Open-ended Lines	Other Components [2]
Wellhead	11	0	36	1	0
Separator	34	0	106	6	2
Meters/piping	14	0	51	1	1
Heater-Treater	0	0	0	0	0
Header	0	0	0	0	0
In-line Heaters	14	0	65	2	1
Dehydrators	24	0	90	2	2
Compressors	73	0	179	3	4

Table 10-3 Facility Equipment Counts [3]

Major Equipment	Oil Production	Gas Production
Wellhead	436	436
Separator	0	0
Meters/piping	98	98
Heater-Treater	29	29
Header	0	0
In-line Heaters	0	0
Dehydrators	11	11
Compressors	9	9

Table 10-4 Component Counts - MRR Approach

Component Service	Valve	Flanges	Connectors	Open-ended Lines	Other Components [2]
Light Oil Service	2412	4708	2324	0	436
Gas Service	7094	0	23313	583	156

Table 10-5 Fugitive Emissions Estimate

Liquid Equipment/Service	Oil and Gas Production Operations Emission Factor (Light Oil) [4]	Oil and Gas Production Operations Emission Factor (Gas) [4]	# Light Oil Components	# Gas Components	Reduction Factor [5]	Short-Term Total Emissions [6]	Annual Total Emissions [7]
	(lb/hr/component)	(lb/hr/component)				(lb/hr)	(ton/yr)
Valves	0.0055	0.00992	2412	7094	97%	2.5	11.0
Flanges	0.000243	0.00086	4708	0	97%	0.03	0.15
Open-Ended Lines	0.00309	0.00441	0	583	97%	0.08	0.3
Connectors	0.000463	0.00044	2324	23313	97%	0.3	1.5
Other	0.0165	0.0194	436	156	93%	0.7	3.1
Totals TOC						**3.7**	**16.1**

Table A-10 Emissions Calculations from Tank Batteries

Table 10-6 Flash Gas Analysis Composition

Component	Composition [8]	
	Oil Flash	
	Mol%	Wt %
H2S	0.000	0.000
O2	0.000	0.000
CO2	0.011	0.009
N2	0.000	0.000
C1	1.411	0.420
C2	10.70	5.979
C3	34.54	28.30
i-C4	8.903	9.614
n-C4	24.36	26.30
i-C5	6.043	8.100
n-C5	6.741	9.035
C6	2.847	4.537
C7	1.634	3.016
C8	0.378	0.779
C9	0.071	0.167
C10+	0.007	0.019
Benzene	0.059	0.086
Toluene	0.051	0.087
E-Benzene	0.002	0.004
Xylenes	0.013	0.026
n-C6	1.548	2.478
224Trimethylpentane	0.000	0.000

Table 10-7 Total Fugitive Emissions Based on Gas Analysis Speciation [9]

Pollutant		Emission Rate	
		Uncontrolled	
		(lb/hr/unit)	(tpy/unit)
Criteria Pollutant	VOC	3.5	15.4
HAP	Benzene	0.00	1.38E-02
	Toluene	0.00	1.40E-02
	Ethylbenzene	1.47E-04	6.44E-04
	Xylenes	0.00	4.19E-03
	n-Hexane	0.09	0.4
GHG [10]	CO_2	--	0.1
	CH_4	--	6.8
	CO_2e	--	169.2

Footnotes:

[1] Total fugitive component counts are based on equipment counts at the facility and default average component counts for major crude oil production equipment (40 CFR Part 98, Subpart W, Table W-1C) and major onshore natural gas production equipment (40 CFR Part 98, Subpart W, Table W-1B), for the Western US.

[2] Other components include pressure relief valves and other components associated with tanks and tank batteries.

[3] Note that pneumatic controllers at the facility are instrument air-driven, not gas-driven, therefore they are not included in the fugitive emissions.

[4] Emission factors have been obtained from the TCEQ's website (Emissions Factors for Equipment Leak Fugitive Components; Addendum to RG-360, Table 4).

[5] Reductions based on audio, visual, olfactory (AVO) as surrogate for optical gas imaging (OGI) as required under 40 CFR §60, Subpart OOOOa. Control efficiencies from Texas Commission on Environmental Quality Leak Detection and Repair Program guidance.

[6] Controlled Short-Term ER (lb/hr) = (100% - Reduction Factor) * Σ(Number of Components * Emissions Factor [lb/hr/component]).

[7] Controlled Annual ER (tpy) = Controlled Short-Term ER (lb/hr) * 8,760 (hr/yr) * 50% of year / 2,000 (lb/ton).

[8] Composition based on Chromatograph Extended Analysis - GPA 2286, Job Number: 61194.071 for oil flash. Note that C6 includes 2,3 Dimethylbutane, 2 Methylpentane, 3 Methylpentane, Methylcyclopentane, and Cyclohexane; C7 includes 2-Methylhexane, 3-Methylhexane, Other C7's, n-Heptane, and Methylcyclohexane.

[9] Fugitive emissions are based on the weight percent of the flash gas analysis and the total Total Organic Carbon (TOC) calculated in Table 13-5.

[10] GHG emissions are based on the weight percent of the flash gas analysis. CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

Table A-11 Emissions Calculations from Glycol Dehydrators

Maximum Design Heat Input [1]	1.00	(MMBtu/hr)
Fuel Gas Heating Value [2]	1,306	(Btu/scf)
Fuel Gas Consumption [3]	0.77	(Mscf/hr)
Fuel Sulfur Content [4]	0.003	(gr/Mscf)
Operating Time	8,760	(hrs/year)
Design Capacity [5]	4	(MMscfd)
Lean Glycol Recirculation [5]	3	(lb/gal H_2O)
Condenser Reduction [5]	80%	(%)
Firebox Combustion [5]	75%	(%)

Table A-11a Criteria Pollutant, HAP, and GHG Emissions for Glycol Dehydrator - Reboiler from Sales and Gas Lift Compression

Pollutant		Emission Factor [6]		Emission Rate	
				(lb/hr)	(tpy)
Criteria Pollutants	NOx	128	lb/MMscf	9.80E-02	0.43
	CO	108	lb/MMscf	8.24E-02	0.36
	VOC	5.5	lb/MMscf	4.21E-03	1.84E-02
	SO_2 [7]	8.44E-04	lb/MMscf	6.46E-07	2.83E-06
	PM_{10} [8]	7.6	lb/MMscf	5.82E-03	2.55E-02
	$PM_{2.5}$ [8]	7.6	lb/MMscf	5.82E-03	2.55E-02
HAP	Formaldehyde	0.10	lb/MMscf	7.35E-05	3.22E-04
	Benzene	2.69E-03	lb/MMscf	2.06E-06	9.02E-06
	Toluene	4.35E-03	lb/MMscf	3.33E-06	1.46E-05
	Ethylbenzene	9.50E-03	lb/MMscf	7.27E-06	3.19E-05
	Xylenes	0.027	lb/MMScf	2.08E-05	9.12E-05
	n-Hexane	2.30	lb/MMscf	1.76E-03	7.73E-03
GHG [9]	CO_2	59.0	kg/MMBtu	130.1	569.7
	CH_4	3.00E-03	kg/MMBtu	6.61E-03	0.03
	CO_2e	--	--	--	570.4

Table A-11b VOC, HAP, and GHG Emissions for Glycol Dehydrator - Regenerator Still Vent [10, 11]

Pollutant		Control Efficiency	Emission Rate			
			Uncontrolled		Controlled	
		(%)	(lb/hr)	(tpy)	(lb/hr)	(tpy)
VOC		95%	18.3	79.9	0.91	4.0
HAP	Benzene	95%	1.4	6.1	0.07	0.30
	Toluene	95%	3.0	13.0	0.15	0.65
	Ethylbenzene	95%	0.4	1.8	0.02	0.09
	Xylenes	95%	3.6	15.7	0.18	0.78
	n-Hexane	95%	0.3	1.5	0.02	0.07
GHG [9]	CO_2	95%	0.02	0.1	8.80E-04	3.85E-03
	CH_4	95%	0.25	1.1	0.01	0.06
	CO_2e	N/A	--	27.8	--	1.4

Table A-11 Emissions Calculations from Glycol Dehydrators

Maximum Design Heat Input [1]	1.00	(MMBtu/hr)
Fuel Gas Heating Value [2]	1,306	(Btu/scf)
Fuel Gas Consumption [3]	0.77	(Mscf/hr)
Fuel Sulfur Content [4]	0.003	(gr/Mscf)
Operating Time	8,760	(hrs/year)
Design Capacity [5]	4	(MMscfd)
Lean Glycol Recirculation [5]	3	(lb/gal H_2O)
Condenser Reduction [5]	80%	(%)
Firebox Combustion [5]	75%	(%)

Table A-11c Component-specific Emissions from GRI-GLYCalc Model - Regenerator Still Vent

No.	Component	Emissions (tpy)
1	Hydrogen Sulfide	--
2	Methane	1.1070
3	Ethane	3.5263
4	Propane	6.7649
5	Isobutane	1.8092
6	n-Butane	6.0848
7	Isopentane	1.4467
8	n-Pentane	2.2086
9	Cyclopentane	3.7843
10	n-Hexane	1.4680
11	Cyclohexane	5.6684
12	Other Hexanes	1.2719
13	Heptanes	2.5001
14	Methylcyclohexane	6.6132
15	Benzene	6.0676
16	Toluene	13.0300
17	Ethylbenzene	1.8138
18	Xylenes	15.6521
19	C8+ Heavies	3.7553
-	Carbon Dioxide [12]	0.0771

Table A-11d VOC and HAP Emissions for Glycol Dehydrator - Flash Tank[13]

Pollutant		Control Efficiency	Emission Rate			
			Uncontrolled		Controlled	
		(%)	(lb/hr)	(tpy)	(lb/hr)	(tpy)
VOC		95%	12.0	52.5	0.60	2.6
HAP	Benzene	95%	0.04	0.17	1.91E-03	0.01
	Toluene	95%	0.1	0.24	2.71E-03	0.01
	Ethylbenzene	95%	4.47E-03	0.02	2.24E-04	9.80E-04
	Xylenes	95%	0.03	0.12	1.32E-03	0.01
	n-Hexane	95%	0.3	1.1	0.01	0.06
GHG [9]	CO_2	95%	0.04	0.2	2.05E-03	8.96E-03
	CH_4	95%	6.65	29.1	0.33	1.46
	CO_2e	N/A	--	728.5	--	36.4

Table A-11 Emissions Calculations from Glycol Dehydrators

Maximum Design Heat Input [1]	1.00	(MMBtu/hr)
Fuel Gas Heating Value [2]	1,306	(Btu/scf)
Fuel Gas Consumption [3]	0.77	(Mscf/hr)
Fuel Sulfur Content [4]	0.003	(gr/Mscf)
Operating Time	8,760	(hrs/year)
Design Capacity [5]	4	(MMscfd)
Lean Glycol Recirculation [5]	3	(lb/gal H_2O)
Condenser Reduction [5]	80%	(%)
Firebox Combustion [5]	75%	(%)

Table A-11e Component-specific Emissions from GRI-GLYCalc Model - Flash Tank

No.	Component	Emissions (tpy)
1	Hydrogen Sulfide	--
2	Methane	29.1334
3	Ethane	27.9825
4	Propane	23.9308
5	Isobutane	4.3636
6	n-Butane	11.2796
7	Isopentane	2.3872
8	n-Pentane	2.9442
9	Cyclopentane	1.3405
10	n-Hexane	1.1181
11	Cyclohexane	1.1337
12	Other Hexanes	1.2727
13	Heptanes	0.9659
14	Methylcyclohexane	1.0484
15	Benzene	0.1669
16	Toluene	0.2377
17	Ethylbenzene	0.0196
18	Xylenes	0.1156
19	C8+ Heavies	0.1556
-	Carbon Dioxide [12]	0.1791

Table A-11f Total Criteria Pollutant, HAP, and GHG Emissions for Glycol Dehydrators

Pollutant		Emission Rate			
		Uncontrolled		Controlled	
		(lb/hr)	(tpy)	(lb/hr)	(tpy)
Criteria Pollutants	NO_x	0.10	0.43	0.10	0.43
	CO	0.08	0.36	0.08	0.36
	VOC	30.24	132.4	1.5	6.6
	SO_2	6.46E-07	2.83E-06	6.46E-07	2.83E-06
	PM_{10}	5.82E-03	0.03	0.01	0.03
	$PM_{2.5}$	5.82E-03	0.03	0.01	0.03
HAP	Formaldehyde	7.35E-05	3.22E-04	7.35E-05	3.22E-04
	Benzene	1.42	6.2	0.07	0.31
	n-Hexane	0.59	2.6	0.03	0.14
	Toluene	3.0	13.3	0.15	0.66
	Ethylbenzene	0.42	1.8	0.02	0.09
	Xylenes	3.6	15.8	0.18	0.79
GHG [9]	CO_2	130.1	570.0	130.1	569.7
	CH_4	6.91	30.3	0.35	1.54
	CO_2e	--	1,327	--	608.3

Table A-11 Emissions Calculations from Glycol Dehydrators

Maximum Design Heat Input [1]	1.00	(MMBtu/hr)
Fuel Gas Heating Value [2]	1,306	(Btu/scf)
Fuel Gas Consumption [3]	0.77	(Mscf/hr)
Fuel Sulfur Content [4]	0.003	(gr/Mscf)
Operating Time	8,760	(hrs/year)
Design Capacity [5]	4	(MMscfd)
Lean Glycol Recirculation [5]	3	(lb/gal H_2O)
Condenser Reduction [5]	80%	(%)
Firebox Combustion [5]	75%	(%)

Table A-11g Speciated PM Emissions for Glycol Dehydrators

Speciated Pollutant [15]		Emission Rate			
		Uncontrolled		Controlled	
		(lb/hr)	(tpy)	(lb/hr)	(tpy)
Speciated	Filterable PM	1.45E-03	6.37E-03	1.45E-03	6.37E-03
	Condensible PM	4.36E-03	0.02	4.36E-03	0.02
	Elemental Carbon (EC)	1.45E-03	6.37E-03	1.45E-03	6.37E-03
	Soils	--	--	--	--
	Sulfate (SO_4)	3.23E-07	1.42E-06	3.23E-07	1.42E-06
	Organic Carbon (OC)	4.36E-03	0.02	4.36E-03	0.02

Footnotes:

[1] Maximum design heat input based on proposed design.

[2] Fuel gas heating value assumes that "Meter Run Gas" composition from the Cotton Hills gas analysis

[3] Fuel gas consumption (Mscf/hr) = (1.0 MMBtu/hr x 1,000) / (1,306 Btu/scf)

[4] Fuel sulfur content based on Separator Heater value.

[5] Design capacity, lean glycol regeneration rate, condenser reduction, and firebox combustion based on specifications

[6] Emission factors based on AP-42 Section 1.4, "Natural Gas Combustion". NOx and CO emission factors are based on Table 1.4-1 for "Small Boilers". VOC, SO_2, PM_{10}, and $PM_{2.5}$ emission factors are based on Table 1.4-2. Note that the SO_2 emission factor is converted based on Table 1.4-2 Footnote D. HAP emission factors, except ethylbenzene and xylenes, are based on Table 1.4-3. Note that the HAP emission factors are converted based on ratios of the actual fuel gas heating value and the average fuel gas heating value. Ethylbenzene and xylene emission factors based on California Air Resources Board (CARB) Natural Gas Combustion Factors.

[7] SO_2 emission factor is converted to a different natural gas sulfur content by multiplying the SO_2 emission factor in Table 1.4-2 by the ratio of the site-specific sulfur content (grains/10^6 scf) to 2,000 grains/10^6 scf. Example calculation: emission factor (lb/MMscf) = fuel sulfur content (gr/Mscf) / 7,000 gr/lb x (Mscf/MMscf) x (64 lb/lb-mol SO2/32 lb/lb-mol S) x 1,000

[8] PM_{10} assumed to equal $PM_{2.5}$.

[9] GHG emissions for methane based on GRI-GLYCalc.

[10] VOC and HAP emissions from the Regenerator Still Vent based on GRI-GLYCalc.

[11] Control efficiency for the Regenerator Still Vent based on condenser reduction and firebox combustion controls

[12] CO_2 emissions based on Regenerator Overheads Stream and Flash Tank Off Gas Stream in the GRI-GLYCalc results.

[13] Emission factors for the Flash Tank based on GRI-GLYCalc.

[14] Note that NOx, CO, SO_2, PM_{10}, $PM_{2.5}$, and formaldehyde emissions are only emitted from the Reboiler from Sales and Gas Lift Compression. Additionally, n-Hexane emissions are only emitted from the Regenerator Still Vent and the Flash Tank. VOC, benzene, and toluene are emitted from all three (3) glycol dehydrators.

[15] Speciated pollutants are for modeling purposes only. Speciations are based on the National Park Service (NPS) "Particulate Matter Speciation" web page for natural gas fired combustion turbines. The following speciations apply:
Filterable PM is 25% of total PM;
Condensible PM is 75% of total PM;
Elemental Carbon (EC) is 100% of filterable PM;
Soils are not applicable for natural gas fired combustion engines;
Sulfates (SO_4) are 33.3% (1/3) of SO_2 and adjusted for differences in molecular weights (multiplied by lb-mol for SO_4/SO_2 = 96/64);
and, Organic Carbon (OC) is the difference of sulfates (SO_4) and condensible PM.

Table A-12 Emission Calculations from Natural-Gas Gas Compressors

BHP - Small Compressor [1]	1,380	(bhp/unit)
BHP - Large Compressor [2]	5,000	(bhp/unit)
Operating Time	8,760	(hrs/yr)
BSFC - Small Compressor [1]	6,537	Btu/bhp-hr
BSFC - Large Compressor [2]	6,537	Btu/bhp-hr

Table A-12a Criteria Pollutant, HAP, and GHG Emissions for Small Compressors

Pollutant		Emission Factor [3]		Control Efficiency [4]	Maximum Emission Rate			
					Uncontrolled		Controlled	
				(%)	(lb/hr/unit)	(tpy/unit)	(lb/hr/unit)	(tpy/unit)
Criteria Pollutant	NO_x	0.50	g/bhp-hr		1.5	6.7	1.5	6.7
	CO	3.00	g/bhp-hr	94.3	9.1	40.0	0.52	2.3
	VOC	1.03	g/bhp-hr	56.3	3.1	13.7	1.4	6.0
	SO_2	8.31E-03	g/bhp-hr		0.03	0.11	0.03	0.11
	PM_{10}	7.71E-05	lb/MMBtu		6.96E-04	3.05E-03	6.96E-04	3.05E-03
	$PM_{2.5}$	7.71E-05	lb/MMBtu		6.96E-04	3.05E-03	6.96E-04	3.05E-03
HAP	Formaldehyde	0.39	g/bhp-hr	84.6	1.19	5.2	0.18	0.80
	Benzene	4.40E-04	lb/MMBtu		3.97E-03	0.02	3.97E-03	0.02
	Toluene	4.08E-04	lb/MMBtu		3.68E-03	0.02	3.68E-03	0.02
	Ethylbenzene	3.97E-05	lb/MMBtu		3.58E-04	1.57E-03	3.58E-04	1.57E-03
	Xylenes	1.84E-04	lb/MMBtu		1.66E-03	0.01	1.66E-03	0.01
	n-Hexane	1.11E-03	lb/MMBtu		0.01	0.04	0.01	0.04
GHG [5]	CO_2	59	kg/MMBtu		1,173	5,139	1,173	5,139
	CH_4	3.00E-03	kg/MMBtu		0.06	0.26	0.06	0.26
	N_2O	6.00E-04	kg/MMBtu		0.01	0.05	0.01	0.05
	CO_2e	--	--		--	5,162	--	5,162

Table A-12b Speciated PM Emissions for Small Compressors

Speciated Pollutant [6]		Emission Rate			
		Uncontrolled		Controlled	
		(lb/hr/unit)	(tpy/unit)	(lb/hr/unit)	(tpy/unit)
Speciated	Filterable PM	1.74E-04	7.62E-04	1.74E-04	7.62E-04
	Condensible PM	5.22E-04	2.28E-03	5.22E-04	2.28E-03
	Elemental Carbon (EC)	1.74E-04	7.62E-04	1.74E-04	7.62E-04
	Soils	--	--	--	--
	Sulfate (SO_4)	0.01	0.06	0.01	0.06
	Organic Carbon (OC)	0.01	0.05	0.01	0.05

Table A-12c Criteria Pollutant, HAP, and GHG Emissions for Large Compressors

Pollutant		Emission Factor [3]		Control Efficiency [4]	Emission Rate			
					Uncontrolled		Controlled	
				(%)	(lb/hr/unit)	(tpy/unit)	(lb/hr/unit)	(tpy/unit)
Criteria Pollutant	NO_x	0.30	g/bhp-hr		3.3	14.5	3.3	14.5
	CO	2.97	g/bhp-hr	93.9	32.7	143.4	2.0	8.7
	VOC	1.51	g/bhp-hr	43.6	16.6	72.9	9.4	41.1
	SO_2	0.01	g/bhp-hr		0.09	0.01	0.09	0.01
	PM_{10}	7.71E-05	lb/MMBtu		2.52E-03	0.01	2.52E-03	0.01
	$PM_{2.5}$	7.71E-05	lb/MMBtu		2.52E-03	0.01	2.52E-03	0.01
HAP	Formaldehyde	0.14	g/bhp-hr	78.5	1.5	6.8	0.33	1.5
	Benzene	4.40E-04	lb/MMBtu		0.01	0.06	0.01	0.06
	Toluene	4.08E-04	lb/MMBtu		0.01	0.06	0.01	0.06
	Ethylbenzene	3.97E-05	lb/MMBtu		1.30E-03	0.01	1.30E-03	0.01
	Xylenes	1.84E-04	lb/MMBtu		0.01	0.03	0.01	0.03
	n-Hexane	1.11E-03	lb/MMBtu		0.04	0.16	0.04	0.16
GHG [5]	CO_2	59	kg/MMBtu		4,251	18,621	4,251	18,621
	CH_4	3.00E-03	kg/MMBtu		0.22	0.95	0.22	0.95
	N_2O	6.00E-04	kg/MMBtu		0.04	0.19	0.04	0.19
	CO_2e	--	--		--	18,701	--	18,701

Table A-12 Emission Calculations from Natural-Gas Gas Compressors

BHP - Small Compressor [1]	1,380	(bhp/unit)
BHP - Large Compressor [2]	5,000	(bhp/unit)
Operating Time	8,760	(hrs/yr)
BSFC - Small Compressor [1]	6,537	Btu/bhp-hr
BSFC - Large Compressor [2]	6,537	Btu/bhp-hr

Table A-12d Speciated PM Emissions for Large Compressors

Speciated Pollutant [6]		Emission Rate			
		Uncontrolled		Controlled	
		(lb/hr/unit)	(tpy/unit)	(lb/hr/unit)	(tpy/unit)
Speciated	Filterable PM	6.30E-04	2.76E-03	6.30E-04	2.76E-03
	Condensible PM	1.89E-03	8.28E-03	1.89E-03	8.28E-03
	Elemental Carbon (EC)	6.30E-04	2.76E-03	6.30E-04	2.76E-03
	Soils	--	--	--	--
	Sulfate (SO_4)	0.05	4.15E-03	0.05	4.15E-03
	Organic Carbon (OC)	0.04	4.13E-03	0.04	4.13E-03

Footnotes:

[1] Bhp and design capacity for the small compressor based on specifications. Note that the design capacity for the small compressor is assumed to be the same as the large compressor.

[2] Bhp and design capacity for the large compressor based on specifications.

[3] NOx, CO, VOC, and formaldehyde emission factors based on manufactuer's specifications. VOC assumed equal to NMHC. SO_2 emission factor based on Federal Energy Regulatory Commission (FERC) standard of 2 gr/100 scf. PM emission factors based on AP-42, Section 3.2, "Natural Gas-fired Reciprocating Engines", Table 3.2-2. HAP emission factors based on AP-42 Section 3.2, "Natural Gas-fired Reciprocating Engines", Table 3.2-2.

[4] Control efficiency based on manufacturer specifications for oxidation catalyst.

[5] GHG emission factors are based on the following sources: 40 CFR Part 98, Table C-1 for CO_2 (for distillate fuel oil No. 2) and Table C-2 for CH_4 and N_2O (both for fuel gas). CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[6] Speciated pollutants are for modeling purposes only. Speciations are based on the National Park Service (NPS) "Particulate Matter Speciation" web page for natural gas fired combustion turbines. The following speciations apply:
Filterable PM is 25% of total PM;
Condensible PM is 75% of total PM;
Elemental Carbon (EC) is 100% of filterable PM;
Soils are not applicable for natural gas fired combustion engines;
Sulfates (SO_4) are 33.3% (1/3) of SO_2 and adjusted for differences in molecular weights (multiplied by lb-mol for SO_4/SO_2 = 96/64); and,
Organic Carbon (OC) is the difference of sulfates (SO_4) and condensible PM.

Table A-13 Emissions Calculations for Fugitive Emissions from Pipelines

Pipeline Gas MW [1]	21.24	(lb/lbmol)
Operating Time	8,760	(hrs/yr)
Emission Factor - Protected Pipeline [2]	0.47	(scf/hr/mile)
Emission Factor - Composite Pipeline [2]	2.50	(scf/hr/mile)
Heating Value [3]	1,020	(Btu/scf)
Design Capacity - Protected Pipeline [4]	4.79E-04	(MMBtu/hr/mile)
Design Capacity - Composite Pipeline [4]	2.55E-03	(MMBtu/hr/mile)

Table A-13a Criteria Pollutant and HAP Emissions for Pipelines

Pollutant		Emission Rate			
		Protected		Composite	
		(lb/hr/mile)	(tpy/mile)	(lb/hr/mile)	(tpy/mile)
Criteria Pollutant	VOC	5.87E-03	0.03	0.03	0.14
HAP	Benzene	6.85E-06	3.00E-05	3.64E-05	1.60E-04
	Toluene	1.26E-05	5.54E-05	6.73E-05	2.95E-04
	Ethylbenzene	1.32E-06	5.77E-06	7.01E-06	3.07E-05
	Xylenes	9.22E-06	4.04E-05	4.90E-05	2.15E-04
	n-Hexane	1.37E-04	5.99E-04	7.27E-04	3.18E-03

Table A-13b GHG Emissions for Pipelines

Pollutant		Emission Rate			
		Protected		Composite	
		(lb/hr/mile)	(tpy/mile)	(lb/hr/mile)	(tpy/mile)
GHG [2]	CO_2	4.08E-05	1.79E-04	2.17E-04	9.51E-04
	CH_4	0.02	0.07	0.08	0.36
	CO_2e	--	1.7	--	9.0

Table A-13c Gas Sample Composition for Pipelines

No.	Component	Composition	
		Mol%	Wt%
1	H2S	0.000	--
2	O2	--	--
3	CO2	0.075	0.155
4	N2	0.837	1.104
5	C1	77.739	58.715
6	C2	12.345	17.476
7	C3	5.540	11.501
8	i-C4	0.673	1.842
9	n-C4	1.482	4.055
10	i-C5	0.283	0.961
11	n-C5	0.326	1.107
12	C6	0.278	1.118
13	C7	0.119	0.558
14	C8	0.057	0.298
15	C9	0.018	0.107
16	C10+	0.015	0.105
17	Benzene	0.007	0.026
18	Toluene	0.011	0.048
19	E-Benzene	0.001	0.005
20	Xylenes	0.007	0.035
21	n-C6	0.128	0.519
22	224Trimethylpentane	--	--

Table A-13 Emissions Calculations for Fugitive Emissions from Pipelines

Pipeline Gas MW [1]	21.24	(lb/lbmol)
Operating Time	8,760	(hrs/yr)
Emission Factor - Protected Pipeline [2]	0.47	(scf/hr/mile)
Emission Factor - Composite Pipeline [2]	2.50	(scf/hr/mile)
Heating Value [3]	1,020	(Btu/scf)
Design Capacity - Protected Pipeline [4]	4.79E-04	(MMBtu/hr/mile)
Design Capacity - Composite Pipeline [4]	2.55E-03	(MMBtu/hr/mile)

Footnotes:

[1] Pipeline gas molecular weight based on gas analysis.

[2] Emission factors based on 40 CFR Part 98, Subpart W, Table W-1A. CO_2e are calculated based on Equation A-1 in 40 CFR Part 98, Subpart W, which are the sum of the product of the mass emissions of each GHG and the global warming potential (GWP) for each GHG, which are listed in Table A-1. Mass emissions are in units of metric tons per year.

[3] Heating value based on average gross heating value of natural gas, 1,020 Btu/scf, based on AP-42, Section 1.4, "Natural Gas Combustion".

[4] Design capacities for protected and composite pipelines based on gas analysis and calculated using average heating value.

Table A-14 Predicted Annual Emissions of NO_X for the Hayhurst Development (per year)

Emissions per well	
Drill Rig Tier 2 (tons/well) =	2.77
Drill Rig Tier 4 (tons/well) =	1.58
Completions Rig Tier 2 (tons/well) =	0.16
Completions Rig - Tier 4 (tons/well) =	0.02
Hydraulic Fracturing - Tier 2 (tons/well) =	5.97
Hydraulic Fracturing - Tier 4 (tons/well) =	3.40
Max Dehydrator Emissions (tpy) =	4.72
Max Compressor Emissions (tpy) =	114.72
Max Separator Emissions (tpy) =	102.15

Year	No. of Wells Drilled		Emissions (tons/year)														
			Drilling and Completion				Hydraulic Fracturing		Total Drilling Emissions		Production Emissions						TOTAL
			Tier 2		Tier 4		Tier 2	Tier 4	Tier 2	Tier 4	Dehydrator Emissions (25% per year)	% Max Gas Production [1]	Compression	% Max Separator Capacity [2]	Separator Heater Emissions	Total Production	
	Tier 2	Tier 4	Drill Rig	Completions Rig	Drill Rig	Completions Rig											
2017	11	11	30.52	1.74	17.40	0.19	65.64	37.42	97.90	55.02	-	0.0%	-	0.0%	-	-	152.92
2018	11	22	30.52	1.74	34.81	0.38	65.64	74.85	97.90	110.03	1.18	4.1%	4.72	8.2%	8.37	14.27	222.21
2019	11	33	30.52	1.74	52.21	0.57	65.64	112.27	97.90	165.05	2.36	17.2%	19.72	13.1%	13.42	35.50	298.45
2020	0	44	-	-	69.61	0.76	-	149.69	-	220.07	3.54	28.9%	33.11	19.6%	20.05	56.70	276.77
2021	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	47.0%	53.90	27.7%	28.31	86.94	307.01
2022	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	66.6%	76.42	32.3%	33.03	114.18	334.25
2023	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	71.2%	81.73	32.0%	32.66	119.11	339.18
2024	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	85.2%	97.79	37.6%	38.46	140.97	361.04
2025	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	100.0%	114.72	33.6%	34.36	153.80	373.87
2026	0	44	-	-	69.61	0.76	-	149.69	-	220.07	4.72	99.6%	114.27	26.9%	27.43	146.42	366.49
2027	0	29	-	-	45.88	0.50	-	98.66	-	145.05	4.72	89.2%	102.32	20.0%	20.45	127.49	272.53
2028	0	0	-	-	-	-	-	-	-	-	4.72	79.2%	90.80	16.5%	16.85	112.37	112.37
2029	0	0	-	-	-	-	-	-	-	-	4.72	71.0%	81.40	14.2%	14.55	100.68	100.68
2030	0	0	-	-	-	-	-	-	-	-	4.72	64.2%	73.63	12.6%	12.87	91.22	91.22
2031	0	0	-	-	-	-	-	-	-	-	4.72	58.2%	66.79	11.3%	11.53	83.04	83.04
2032	0	0	-	-	-	-	-	-	-	-	4.72	53.5%	61.34	10.2%	10.41	76.48	76.48
2033	0	0	-	-	-	-	-	-	-	-	4.72	49.3%	56.52	9.2%	9.45	70.69	70.69
2034	0	0	-	-	-	-	-	-	-	-	4.72	45.4%	52.10	8.4%	8.59	65.41	65.41
2035	0	0	-	-	-	-	-	-	-	-	4.72	41.8%	47.91	7.6%	7.81	60.44	60.44
2036	0	0	-	-	-	-	-	-	-	-	4.72	38.4%	44.00	7.0%	7.11	55.84	55.84

Notes:

[1] Gas production as a fraction of maximum project design provided by Chevron (September 8, 2016). Compressor usage is directly proportional to gas production.

[2] Separator usage is proportional to oil production relative to design capacity. Max separator usage provided by Chevron (September 8, 2016).

Note: Construction emissions are not included since there are no NOx emissions emitted.

Table A-15 Predicted Annual Emissions of CO for the Hayhurst Development (per year)

Emissions per well	
Drill Rig Tier 2 (tons/well) =	1.58
Drill Rig Tier 4 (tons/well) =	1.58
Completions Rig Tier 2 (tons/well) =	9.03E-02
Completions Rig - Tier 4 (tons/well) =	9.03E-02
Hydraulic Fracturing - Tier 2 (tons/well) =	3.40
Hydraulic Fracturing - Tier 4 (tons/well) =	3.40
Max Dehydrator Emissions (tpy) =	3.97
Max Compressor Emissions (tpy) =	65.79
Max Separator Emissions (tpy) =	85.81

Year	No. of Wells Drilled		Emissions (tons/year)														
			Drilling and Completion				Hydraulic Fracturing		Total Drilling Emissions		Production Emissions						TOTAL
			Tier 2		Tier 4		Tier 2	Tier 4	Tier 2	Tier 4	Dehydrator Emissions (25% per year)	% Max Gas Production [1]	Compression	% Max Separator Capacity [2]	Separator Heater Emissions	Total Production	
	Tier 2	Tier 4	Drill Rig	Completions Rig	Drill Rig	Completions Rig											
2017	11	11	17.40	0.99	17.40	0.99	37.42	37.42	55.82	55.82	-	0.0%	-	0.0%	-	-	111.64
2018	11	22	17.40	0.99	34.81	1.99	37.42	74.85	55.82	111.64	0.99	4.1%	2.71	8.2%	7.03	10.73	178.19
2019	11	33	17.40	0.99	52.21	2.98	37.42	112.27	55.82	167.46	1.98	17.2%	11.31	13.1%	11.27	24.56	247.84
2020	0	44	-	-	69.61	3.97	-	149.69	-	223.28	2.98	28.9%	18.99	19.6%	16.84	38.81	262.08
2021	0	44	-	-	69.61	3.97	-	149.69	-	223.28	3.97	47.0%	30.91	27.7%	23.78	58.66	281.94
2022	0	44	-	-	69.61	3.97	-	149.69	-	223.28	3.97	66.6%	43.83	32.3%	27.75	75.54	298.82
2023	0	44	-	-	69.61	3.97	-	149.69	-	223.28	3.97	71.2%	46.87	32.0%	27.44	78.27	301.55
2024	0	44	-	-	69.61	3.97	-	149.69	-	223.28	3.97	85.2%	56.08	37.6%	32.30	92.35	315.63
2025	0	44	-	-	69.61	3.97	-	149.69	-	223.28	3.97	100.0%	65.79	33.6%	28.86	98.62	321.89
2026	0	44	-	-	69.61	3.97	-	149.69	-	223.28	3.97	99.6%	65.53	26.9%	23.04	92.54	315.82
2027	0	29	-	-	45.88	2.62	-	98.66	-	147.16	3.97	89.2%	58.68	20.0%	17.18	79.82	226.98
2028	0	0	-	-	-	-	-	-	-	-	3.97	79.2%	52.07	16.5%	14.15	70.19	70.19
2029	0	0	-	-	-	-	-	-	-	-	3.97	71.0%	46.68	14.2%	12.23	62.87	62.87
2030	0	0	-	-	-	-	-	-	-	-	3.97	64.2%	42.23	12.6%	10.81	57.00	57.00
2031	0	0	-	-	-	-	-	-	-	-	3.97	58.2%	38.30	11.3%	9.69	51.95	51.95
2032	0	0	-	-	-	-	-	-	-	-	3.97	53.5%	35.18	10.2%	8.75	47.89	47.89
2033	0	0	-	-	-	-	-	-	-	-	3.97	49.3%	32.41	9.2%	7.93	44.32	44.32
2034	0	0	-	-	-	-	-	-	-	-	3.97	45.4%	29.88	8.4%	7.21	41.06	41.06
2035	0	0	-	-	-	-	-	-	-	-	3.97	41.8%	27.47	7.6%	6.56	38.00	38.00
2036	0	0	-	-	-	-	-	-	-	-	3.97	38.4%	25.24	7.0%	5.97	35.17	35.17

Notes:

[1] Gas production as a fraction of maximum project design provided by Chevron (September 8, 2016). Compressor usage is directly proportional to gas production.

[2] Separator usage is proportional to oil production relative to design capacity. Max separator usage provided by Chevron (September 8, 2016).

Note: Construction emissions are not included since there are no NOx emissions emitted.

Table A-16 Predicted Annual Emissions of SO_2 for the Hayhurst Development (per year)

Emissions per well	
Drill Rig Tier 2 (tons/well) =	2.87E-03
Drill Rig Tier 4 (tons/well) =	2.87E-03
Completions Rig Tier 2 (tons/well) =	1.64E-04
Completions Rig - Tier 4 (tons/well) =	1.64E-04
Hydraulic Fracturing - Tier 2 (tons/well) =	6.18E-03
Hydraulic Fracturing - Tier 4 (tons/well) =	6.18E-03
Max Dehydrator Emissions (tpy) =	3.11E-05
Max Compressor Emissions (tpy) =	0.28
Max Separator Emissions (tpy) =	6.74E-04

Year	No. of Wells Drilled		Emissions (tons/year)														
			Drilling and Completion				Hydraulic Fracturing		Total Drilling Emissions		Production Emissions						TOTAL
			Tier 2		Tier 4		Tier 2	Tier 4	Tier 2	Tier 4	Dehydrator Emissions (25% per year)	% Max Gas Production [1]	Compression	% Max Separator Capacity [2]	Separator Heater Emissions	Total Production	
	Tier 2	Tier 4	Drill Rig	Completions Rig	Drill Rig	Completions Rig											
2017	11	11	0.03	0.00	0.03	0.00	0.07	0.07	0.10	0.10	-	0.0%	-	0.0%	-	-	0.20
2018	11	22	0.03	0.00	0.06	0.00	0.07	0.14	0.10	0.20	0.00	4.1%	0.01	8.2%	0.00	0.01	0.32
2019	11	33	0.03	0.00	0.09	0.01	0.07	0.20	0.10	0.30	0.00	17.2%	0.05	13.1%	0.00	0.05	0.45
2020	0	44	-	-	0.13	0.01	-	0.27	-	0.41	0.00	28.9%	0.08	19.6%	0.00	0.08	0.49
2021	0	44	-	-	0.13	0.01	-	0.27	-	0.41	0.00	47.0%	0.13	27.7%	0.00	0.13	0.54
2022	0	44	-	-	0.13	0.01	-	0.27	-	0.41	0.00	66.6%	0.19	32.3%	0.00	0.19	0.59
2023	0	44	-	-	0.13	0.01	-	0.27	-	0.41	0.00	71.2%	0.20	32.0%	0.00	0.20	0.61
2024	0	44	-	-	0.13	0.01	-	0.27	-	0.41	0.00	85.2%	0.24	37.6%	0.00	0.24	0.64
2025	0	44	-	-	0.13	0.01	-	0.27	-	0.41	0.00	100.0%	0.28	33.6%	0.00	0.28	0.69
2026	0	44	-	-	0.13	0.01	-	0.27	-	0.41	0.00	99.6%	0.28	26.9%	0.00	0.28	0.68
2027	0	29	-	-	0.08	0.00	-	0.18	-	0.27	0.00	89.2%	0.25	20.0%	0.00	0.25	0.52
2028	0	0	-	-	-	-	-	-	-	-	0.00	79.2%	0.22	16.5%	0.00	0.22	0.22
2029	0	0	-	-	-	-	-	-	-	-	0.00	71.0%	0.20	14.2%	0.00	0.20	0.20
2030	0	0	-	-	-	-	-	-	-	-	0.00	64.2%	0.18	12.6%	0.00	0.18	0.18
2031	0	0	-	-	-	-	-	-	-	-	0.00	58.2%	0.16	11.3%	0.00	0.16	0.16
2032	0	0	-	-	-	-	-	-	-	-	0.00	53.5%	0.15	10.2%	0.00	0.15	0.15
2033	0	0	-	-	-	-	-	-	-	-	0.00	49.3%	0.14	9.2%	0.00	0.14	0.14
2034	0	0	-	-	-	-	-	-	-	-	0.00	45.4%	0.13	8.4%	0.00	0.13	0.13
2035	0	0	-	-	-	-	-	-	-	-	0.00	41.8%	0.12	7.6%	0.00	0.12	0.12
2036	0	0	-	-	-	-	-	-	-	-	0.00	38.4%	0.11	7.0%	0.00	0.11	0.11

Notes:

[1] Gas production as a fraction of maximum project design provided by Chevron (September 8, 2016). Compressor usage is directly proportional to gas production.

[2] Separator usage is proportional to oil production relative to design capacity. Max separator usage provided by Chevron (September 8, 2016).

Note: Construction emissions are not included since there are no NOx emissions emitted.

Table A-17 Predicted Annual Emissions of PM_{10} for the Hayhurst Development (per year)

Emissions per well	
Drill Rig Tier 2 (tons/well) =	9.13E-02
Drill Rig Tier 4 (tons/well) =	1.83E-02
Completions Rig Tier 2 (tons/well) =	5.21E-03
Completions Rig - Tier 4 (tons/well) =	7.64E-04
Hydraulic Fracturing - Tier 2 (tons/well) =	1.96E-01
Hydraulic Fracturing - Tier 4 (tons/well) =	3.93E-02
Max Dehydrator Emissions (tpy) =	0.28
Max Compressor Emissions (tpy) =	8.34E-02
Max Separator Emissions (tpy) =	6.06

Year	No. of Wells Drilled		Emissions (tons/year)														
			Drilling and Completion				Hydraulic Fracturing		Total Drilling Emissions		Production Emissions						TOTAL
			Tier 2		Tier 4		Tier 2	Tier 4	Tier 2	Tier 4	Dehydrator Emissions (25% per year)	% Max Gas Production [1]	Compression	% Max Separator Capacity [2]	Separator Heater Emissions	Total Production	
	Tier 2	Tier 4	Drill Rig	Completions Rig	Drill Rig	Completions Rig											
2017	11	11	1.00	0.06	0.20	0.01	2.16	0.43	3.22	0.64	-	0.0%	-	0.0%	-	-	3.86
2018	11	22	1.00	0.06	0.40	0.02	2.16	0.86	3.22	1.28	0.07	4.1%	0.00	8.2%	0.50	0.57	5.07
2019	11	33	1.00	0.06	0.60	0.03	2.16	1.30	3.22	1.92	0.14	17.2%	0.01	13.1%	0.80	0.95	6.09
2020	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.21	28.9%	0.02	19.6%	1.19	1.42	3.99
2021	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	47.0%	0.04	27.7%	1.68	2.00	4.56
2022	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	66.6%	0.06	32.3%	1.96	2.30	4.86
2023	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	71.2%	0.06	32.0%	1.94	2.28	4.84
2024	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	85.2%	0.07	37.6%	2.28	2.63	5.20
2025	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	100.0%	0.08	33.6%	2.04	2.40	4.97
2026	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	99.6%	0.08	26.9%	1.63	1.99	4.56
2027	0	29	-	-	0.53	0.02	-	1.14	-	1.69	0.28	89.2%	0.07	20.0%	1.21	1.57	3.26
2028	0	0	-	-	-	-	-	-	-	-	0.28	79.2%	0.07	16.5%	1.00	1.35	1.35
2029	0	0	-	-	-	-	-	-	-	-	0.28	71.0%	0.06	14.2%	0.86	1.20	1.20
2030	0	0	-	-	-	-	-	-	-	-	0.28	64.2%	0.05	12.6%	0.76	1.10	1.10
2031	0	0	-	-	-	-	-	-	-	-	0.28	58.2%	0.05	11.3%	0.68	1.01	1.01
2032	0	0	-	-	-	-	-	-	-	-	0.28	53.5%	0.04	10.2%	0.62	0.94	0.94
2033	0	0	-	-	-	-	-	-	-	-	0.28	49.3%	0.04	9.2%	0.56	0.88	0.88
2034	0	0	-	-	-	-	-	-	-	-	0.28	45.4%	0.04	8.4%	0.51	0.83	0.83
2035	0	0	-	-	-	-	-	-	-	-	0.28	41.8%	0.03	7.6%	0.46	0.78	0.78
2036	0	0	-	-	-	-	-	-	-	-	0.28	38.4%	0.03	7.0%	0.42	0.73	0.73

Notes:

[1] Gas production as a fraction of maximum project design provided by Chevron (September 8, 2016). Compressor usage is directly proportional to gas production.

[2] Separator usage is proportional to oil production relative to design capacity. Max separator usage provided by Chevron (September 8, 2016).

Note: Construction emissions are not included since there are no NOx emissions emitted.

Table A-18 Predicted Annual Emissions of $PM_{2.5}$ for the Hayhurst Development (per year)

Emissions per well	
Drill Rig Tier 2 (tons/well) =	9.13E-02
Drill Rig Tier 4 (tons/well) =	1.83E-02
Completions Rig Tier 2 (tons/well) =	5.21E-03
Completions Rig - Tier 4 (tons/well) =	7.64E-04
Hydraulic Fracturing - Tier 2 (tons/well) =	1.96E-01
Hydraulic Fracturing - Tier 4 (tons/well) =	3.93E-02
Max Dehydrator Emissions (tpy) =	0.28
Max Compressor Emissions (tpy) =	8.34E-02
Max Separator Emissions (tpy) =	6.06

Year	No. of Wells Drilled		Emissions (tons/year)														
			Drilling and Completion				Hydraulic Fracturing		Total Drilling Emissions		Production Emissions						TOTAL
			Tier 2		Tier 4		Tier 2	Tier 4	Tier 2	Tier 4	Dehydrator Emissions (25% per year)	% Max Gas Production [1]	Compression	% Max Separator Capacity [2]	Separator Heater Emissions	Total Production	
	Tier 2	Tier 4	Drill Rig	Completions Rig	Drill Rig	Completions Rig											
2017	11	11	1.00	0.06	0.20	0.01	2.16	0.43	3.22	0.64	-	0.0%	-	0.0%	-	-	3.86
2018	11	22	1.00	0.06	0.40	0.02	2.16	0.86	3.22	1.28	0.07	4.1%	0.00	8.2%	0.50	0.57	5.07
2019	11	33	1.00	0.06	0.60	0.03	2.16	1.30	3.22	1.92	0.14	17.2%	0.01	13.1%	0.80	0.95	6.09
2020	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.21	28.9%	0.02	19.6%	1.19	1.42	3.99
2021	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	47.0%	0.04	27.7%	1.68	2.00	4.56
2022	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	66.6%	0.06	32.3%	1.96	2.30	4.86
2023	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	71.2%	0.06	32.0%	1.94	2.28	4.84
2024	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	85.2%	0.07	37.6%	2.28	2.63	5.20
2025	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	100.0%	0.08	33.6%	2.04	2.40	4.97
2026	0	44	-	-	0.80	0.03	-	1.73	-	2.56	0.28	99.6%	0.08	26.9%	1.63	1.99	4.56
2027	0	29	-	-	0.53	0.02	-	1.14	-	1.69	0.28	89.2%	0.07	20.0%	1.21	1.57	3.26
2028	0	0	-	-	-	-	-	-	-	-	0.28	79.2%	0.07	16.5%	1.00	1.35	1.35
2029	0	0	-	-	-	-	-	-	-	-	0.28	71.0%	0.06	14.2%	0.86	1.20	1.20
2030	0	0	-	-	-	-	-	-	-	-	0.28	64.2%	0.05	12.6%	0.76	1.10	1.10
2031	0	0	-	-	-	-	-	-	-	-	0.28	58.2%	0.05	11.3%	0.68	1.01	1.01
2032	0	0	-	-	-	-	-	-	-	-	0.28	53.5%	0.04	10.2%	0.62	0.94	0.94
2033	0	0	-	-	-	-	-	-	-	-	0.28	49.3%	0.04	9.2%	0.56	0.88	0.88
2034	0	0	-	-	-	-	-	-	-	-	0.28	45.4%	0.04	8.4%	0.51	0.83	0.83
2035	0	0	-	-	-	-	-	-	-	-	0.28	41.8%	0.03	7.6%	0.46	0.78	0.78
2036	0	0	-	-	-	-	-	-	-	-	0.28	38.4%	0.03	7.0%	0.42	0.73	0.73

Notes:

[1] Gas production as a fraction of maximum project design provided by Chevron (September 8, 2016). Compressor usage is directly proportional to gas production.

[2] Separator usage is proportional to oil production relative to design capacity. Max separator usage provided by Chevron (September 8, 2016).

Note: Construction emissions are not included since there are no NOx emissions emitted.

Table A-19 Summary of Predicted Annual Emissions of Criteria Pollutants for the Hayhurst Development (per year)

Year	Emissions (tpy)														
	Drilling and Completion					Production and Transmission					Total				
	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$
2017	152.92	111.64	0.20	3.86	3.86	-	-	-	-	-	152.92	111.64	0.20	3.86	3.86
2018	207.93	167.46	0.30	4.50	4.50	14.27	10.73	0.01	0.57	0.57	222.21	178.19	0.32	5.07	5.07
2019	262.95	223.28	0.41	5.14	5.14	35.50	24.56	0.05	0.95	0.95	298.45	247.84	0.45	6.09	6.09
2020	220.07	223.28	0.41	2.56	2.56	56.70	38.81	0.08	1.42	1.42	276.77	262.08	0.49	3.99	3.99
2021	220.07	223.28	0.41	2.56	2.56	86.94	58.66	0.13	2.00	2.00	307.01	281.94	0.54	4.56	4.56
2022	220.07	223.28	0.41	2.56	2.56	114.18	75.54	0.19	2.30	2.30	334.25	298.82	0.59	4.86	4.86
2023	220.07	223.28	0.41	2.56	2.56	119.11	78.27	0.20	2.28	2.28	339.18	301.55	0.61	4.84	4.84
2024	220.07	223.28	0.41	2.56	2.56	140.97	92.35	0.24	2.63	2.63	361.04	315.63	0.64	5.20	5.20
2025	220.07	223.28	0.41	2.56	2.56	153.80	98.62	0.28	2.40	2.40	373.87	321.89	0.69	4.97	4.97
2026	220.07	223.28	0.41	2.56	2.56	146.42	92.54	0.28	1.99	1.99	366.49	315.82	0.68	4.56	4.56
2027	145.05	147.16	0.27	1.69	1.69	127.49	79.82	0.25	1.57	1.57	272.53	226.98	0.52	3.26	3.26
2028	-	-	-	-	-	112.37	70.19	0.22	1.35	1.35	112.37	70.19	0.22	1.35	1.35
2029	-	-	-	-	-	100.68	62.87	0.20	1.20	1.20	100.68	62.87	0.20	1.20	1.20
2030	-	-	-	-	-	91.22	57.00	0.18	1.10	1.10	91.22	57.00	0.18	1.10	1.10
2031	-	-	-	-	-	83.04	51.95	0.16	1.01	1.01	83.04	51.95	0.16	1.01	1.01
2032	-	-	-	-	-	76.48	47.89	0.15	0.94	0.94	76.48	47.89	0.15	0.94	0.94
2033	-	-	-	-	-	70.69	44.32	0.14	0.88	0.88	70.69	44.32	0.14	0.88	0.88
2034	-	-	-	-	-	65.41	41.06	0.13	0.83	0.83	65.41	41.06	0.13	0.83	0.83
2035	-	-	-	-	-	60.44	38.00	0.12	0.78	0.78	60.44	38.00	0.12	0.78	0.78
2036	-	-	-	-	-	55.84	35.17	0.11	0.73	0.73	55.84	35.17	0.11	0.73	0.73

APPENDIX B

PROJECT-SPECIFIC EMISSIONS CALCULATIONS SUPPORTING DATA

GRI-GLYCalc VERSION 4.0 - AGGREGATE CALCULATIONS REPORT

Case Name:
File Name: C:\ProgramData\Gas Research Institute\GRI-GLYCalc4\Hayhurst Dev.ddf
Date: April 20, 2016

DESCRIPTION:

Description:

Annual Hours of Operation: 8760.0 hours/yr

EMISSIONS REPORTS:

UNCONTROLLED REGENERATOR EMISSIONS

Component	lbs/hr	lbs/day	tons/yr
Methane	0.2527	6.066	1.1070
Ethane	0.8051	19.322	3.5263
Propane	1.5445	37.068	6.7649
Isobutane	0.4131	9.913	1.8092
n-Butane	1.3892	33.342	6.0848
Isopentane	0.3303	7.927	1.4467
n-Pentane	0.5043	12.102	2.2086
Cyclopentane	0.8640	20.736	3.7843
n-Hexane	0.3352	8.044	1.4680
Cyclohexane	1.2942	31.060	5.6684
Other Hexanes	0.2904	6.969	1.2719
Heptanes	0.5708	13.699	2.5001
Methylcyclohexane	1.5099	36.237	6.6132
Benzene	1.3853	33.247	6.0676
Toluene	2.9749	71.397	13.0300
Ethylbenzene	0.4141	9.939	1.8138
Xylenes	3.5735	85.765	15.6521
C8+ Heavies	0.8574	20.577	3.7553
Total Emissions	19.3087	463.410	84.5723
Total Hydrocarbon Emissions	19.3087	463.410	84.5723
Total VOC Emissions	18.2509	438.022	79.9390
Total HAP Emissions	8.6830	208.392	38.0315
Total BTEX Emissions	8.3478	200.348	36.5635

FLASH TANK OFF GAS

Component	lbs/hr	lbs/day	tons/yr
Methane	6.6515	159.635	29.1334
Ethane	6.3887	153.329	27.9825
Propane	5.4637	131.128	23.9308
Isobutane	0.9963	23.910	4.3636
n-Butane	2.5752	61.806	11.2796
Isopentane	0.5450	13.081	2.3872
n-Pentane	0.6722	16.133	2.9442
Cyclopentane	0.3061	7.345	1.3405
n-Hexane	0.2553	6.127	1.1181
Cyclohexane	0.2588	6.212	1.1337

Other Hexanes	0.2906	6.974	1.2727
Heptanes	0.2205	5.293	0.9659
Methylcyclohexane	0.2394	5.745	1.0484
Benzene	0.0381	0.914	0.1669
Toluene	0.0543	1.302	0.2377
Ethylbenzene	0.0045	0.107	0.0196
Xylenes	0.0264	0.633	0.1156
C8+ Heavies	0.0355	0.852	0.1556
Total Emissions	25.0219	600.526	109.5961
Total Hydrocarbon Emissions	25.0219	600.526	109.5961
Total VOC Emissions	11.9818	287.562	52.4801
Total HAP Emissions	0.3785	9.084	1.6578
Total BTEX Emissions	0.1232	2.957	0.5397

EQUIPMENT REPORTS:

ABSORBER

NOTE: Because the Calculated Absorber Stages was below the minimum allowed, GRI-GLYCalc has set the number of Absorber Stages to 1.25 and has calculated a revised Dry Gas Dew Point.

Calculated Absorber Stages:	1.25	
Calculated Dry Gas Dew Point:	6.43	lbs. H2O/MMSCF
Temperature:	120.0	deg. F
Pressure:	1300.0	psig
Dry Gas Flow Rate:	26.0000	MMSCF/day
Glycol Losses with Dry Gas:	33.9213	lb/hr
Wet Gas Water Content:	Saturated	
Calculated Wet Gas Water Content:	82.48	lbs. H2O/MMSCF
Specified Lean Glycol Recirc. Ratio:	3.00	gal/lb H2O

Component	Remaining in Dry Gas	Absorbed in Glycol
Water	7.78%	92.22%
Carbon Dioxide	99.76%	0.24%
Nitrogen	99.96%	0.04%
Methane	99.97%	0.03%
Ethane	99.95%	0.05%
Propane	99.95%	0.05%
Isobutane	99.95%	0.05%
n-Butane	99.95%	0.05%
Isopentane	99.96%	0.04%
n-Pentane	99.95%	0.05%
Cyclopentane	99.81%	0.19%
n-Hexane	99.95%	0.05%
Cyclohexane	99.78%	0.22%
Other Hexanes	99.96%	0.04%
Heptanes	99.94%	0.06%
Methylcyclohexane	99.84%	0.16%
Benzene	98.01%	1.99%
Toluene	98.20%	1.80%
Ethylbenzene	98.47%	1.53%
Xylenes	97.95%	2.05%

C8+ Heavies	99.97%	0.03%

FLASH TANK

Flash Control: Vented to atmosphere
Flash Temperature: 135.0 deg. F
Flash Pressure: 50.0 psig

Component	Left in Glycol	Removed in Flash Gas
Water	99.94%	0.06%
Carbon Dioxide	30.08%	69.92%
Nitrogen	3.49%	96.51%
Methane	3.66%	96.34%
Ethane	11.19%	88.81%
Propane	22.04%	77.96%
Isobutane	29.31%	70.69%
n-Butane	35.04%	64.96%
Isopentane	38.04%	61.96%
n-Pentane	43.15%	56.85%
Cyclopentane	73.97%	26.03%
n-Hexane	56.98%	43.02%
Cyclohexane	83.87%	16.13%
Other Hexanes	50.48%	49.52%
Heptanes	72.27%	27.73%
Methylcyclohexane	86.86%	13.14%
Benzene	97.46%	2.54%
Toluene	98.35%	1.65%
Ethylbenzene	99.04%	0.96%
Xylenes	99.36%	0.64%
C8+ Heavies	96.50%	3.50%

REGENERATOR

No Stripping Gas used in regenerator.

Component	Remaining in Glycol	Distilled Overhead
Water	29.49%	70.51%
Carbon Dioxide	0.00%	100.00%
Nitrogen	0.00%	100.00%
Methane	0.00%	100.00%
Ethane	0.00%	100.00%
Propane	0.00%	100.00%
Isobutane	0.00%	100.00%
n-Butane	0.00%	100.00%
Isopentane	1.31%	98.69%
n-Pentane	1.16%	98.84%
Cyclopentane	0.68%	99.32%
n-Hexane	0.88%	99.12%
Cyclohexane	3.82%	96.18%
Other Hexanes	1.98%	98.02%
Heptanes	0.69%	99.31%
Methylcyclohexane	4.61%	95.39%

Benzene	5.13%	94.87%
Toluene	8.03%	91.97%
Ethylbenzene	10.50%	89.50%
Xylenes	12.97%	87.03%
C8+ Heavies	12.46%	87.54%

STREAM REPORTS:

WET GAS STREAM

Temperature: 120.00 deg. F
Pressure: 1314.70 psia
Flow Rate: 1.09e+006 scfh

Component	Conc. (vol%)	Loading (lb/hr)
Water	1.74e-001	8.95e+001
Carbon Dioxide	1.90e-002	2.39e+001
Nitrogen	2.74e+000	2.20e+003
Methane	5.60e+001	2.57e+004
Ethane	1.74e+001	1.50e+004
Propane	1.17e+001	1.47e+004
Isobutane	1.88e+000	3.12e+003
n-Butane	4.41e+000	7.33e+003
Isopentane	1.10e+000	2.27e+003
n-Pentane	1.24e+000	2.55e+003
Cyclopentane	2.99e-001	6.01e+002
n-Hexane	5.19e-001	1.28e+003
Cyclohexane	2.99e-001	7.21e+002
Other Hexanes	5.99e-001	1.48e+003
Heptanes	4.99e-001	1.43e+003
Methylcyclohexane	3.79e-001	1.07e+003
Benzene	3.19e-002	7.14e+001
Toluene	6.39e-002	1.68e+002
Ethylbenzene	8.98e-003	2.73e+001
Xylenes	5.79e-002	1.76e+002
C8+ Heavies	5.49e-001	2.67e+003
Total Components	100.00	8.27e+004

DRY GAS STREAM

Temperature: 120.00 deg. F
Pressure: 1314.70 psia
Flow Rate: 1.08e+006 scfh

Component	Conc. (vol%)	Loading (lb/hr)
Water	1.35e-002	6.96e+000
Carbon Dioxide	1.90e-002	2.38e+001
Nitrogen	2.75e+000	2.20e+003
Methane	5.61e+001	2.57e+004
Ethane	1.75e+001	1.50e+004
Propane	1.17e+001	1.47e+004

Isobutane	1.88e+000	3.12e+003
n-Butane	4.42e+000	7.33e+003
Isopentane	1.10e+000	2.27e+003
n-Pentane	1.24e+000	2.55e+003
Cyclopentane	2.99e-001	6.00e+002
n-Hexane	5.20e-001	1.28e+003
Cyclohexane	2.99e-001	7.19e+002
Other Hexanes	6.00e-001	1.48e+003
Heptanes	5.00e-001	1.43e+003
Methylcyclohexane	3.79e-001	1.06e+003
Benzene	3.14e-002	6.99e+001
Toluene	6.28e-002	1.65e+002
Ethylbenzene	8.86e-003	2.69e+001
Xylenes	5.68e-002	1.72e+002
C8+ Heavies	5.50e-001	2.67e+003
Total Components	100.00	8.26e+004

LEAN GLYCOL STREAM

Temperature: 120.00 deg. F
Flow Rate: 4.09e+000 gpm

Component	Conc. (wt%)	Loading (lb/hr)
TEG	9.84e+001	2.26e+003
Water	1.50e+000	3.45e+001
Carbon Dioxide	2.54e-013	5.85e-012
Nitrogen	3.76e-012	8.65e-011
Methane	1.01e-017	2.32e-016
Ethane	1.48e-007	3.40e-006
Propane	1.24e-008	2.85e-007
Isobutane	1.84e-009	4.23e-008
n-Butane	4.27e-009	9.83e-008
Isopentane	1.91e-004	4.40e-003
n-Pentane	2.57e-004	5.91e-003
Cyclopentane	2.56e-004	5.88e-003
n-Hexane	1.29e-004	2.97e-003
Cyclohexane	2.23e-003	5.13e-002
Other Hexanes	2.55e-004	5.87e-003
Heptanes	1.73e-004	3.98e-003
Methylcyclohexane	3.17e-003	7.29e-002
Benzene	3.26e-003	7.49e-002
Toluene	1.13e-002	2.60e-001
Ethylbenzene	2.11e-003	4.86e-002
Xylenes	2.32e-002	5.33e-001
C8+ Heavies	5.31e-003	1.22e-001
Total Components	100.00	2.30e+003

RICH GLYCOL STREAM

Temperature: 120.00 deg. F
Pressure: 1314.70 psia
Flow Rate: 4.35e+000 gpm
NOTE: Stream has more than one phase.

Component	Conc.	Loading

	(wt%)	(lb/hr)
TEG	9.33e+001	2.26e+003
Water	4.83e+000	1.17e+002
Carbon Dioxide	2.41e-003	5.85e-002
Nitrogen	3.56e-002	8.65e-001
Methane	2.85e-001	6.90e+000
Ethane	2.96e-001	7.19e+000
Propane	2.89e-001	7.01e+000
Isobutane	5.81e-002	1.41e+000
n-Butane	1.63e-001	3.96e+000
Isopentane	3.63e-002	8.80e-001
n-Pentane	4.87e-002	1.18e+000
Cyclopentane	4.85e-002	1.18e+000
n-Hexane	2.45e-002	5.93e-001
Cyclohexane	6.61e-002	1.60e+000
Other Hexanes	2.42e-002	5.87e-001
Heptanes	3.28e-002	7.95e-001
Methylcyclohexane	7.51e-002	1.82e+000
Benzene	6.17e-002	1.50e+000
Toluene	1.36e-001	3.29e+000
Ethylbenzene	1.93e-002	4.67e-001
Xylenes	1.70e-001	4.13e+000
C8+ Heavies	4.18e-002	1.01e+000
Total Components	100.00	2.43e+003

FLASH TANK OFF GAS STREAM

Temperature: 135.00 deg. F
Pressure: 64.70 psia
Flow Rate: 3.36e+002 scfh

Component	Conc. (vol%)	Loading (lb/hr)
Water	4.76e-001	7.58e-002
Carbon Dioxide	1.05e-001	4.09e-002
Nitrogen	3.37e+000	8.35e-001
Methane	4.69e+001	6.65e+000
Ethane	2.40e+001	6.39e+000
Propane	1.40e+001	5.46e+000
Isobutane	1.94e+000	9.96e-001
n-Butane	5.01e+000	2.58e+000
Isopentane	8.54e-001	5.45e-001
n-Pentane	1.05e+000	6.72e-001
Cyclopentane	4.94e-001	3.06e-001
n-Hexane	3.35e-001	2.55e-001
Cyclohexane	3.48e-001	2.59e-001
Other Hexanes	3.81e-001	2.91e-001
Heptanes	2.49e-001	2.21e-001
Methylcyclohexane	2.76e-001	2.39e-001
Benzene	5.52e-002	3.81e-002
Toluene	6.66e-002	5.43e-002
Ethylbenzene	4.76e-003	4.47e-003
Xylenes	2.81e-002	2.64e-002
C8+ Heavies	2.36e-002	3.55e-002
Total Components	100.00	2.60e+001

FLASH TANK GLYCOL STREAM

Temperature: 135.00 deg. F
Flow Rate: 4.29e+000 gpm

Component	Conc. (wt%)	Loading (lb/hr)
TEG	9.43e+001	2.26e+003
Water	4.87e+000	1.17e+002
Carbon Dioxide	7.32e-004	1.76e-002
Nitrogen	1.26e-003	3.02e-002
Methane	1.05e-002	2.53e-001
Ethane	3.35e-002	8.05e-001
Propane	6.43e-002	1.54e+000
Isobutane	1.72e-002	4.13e-001
n-Butane	5.79e-002	1.39e+000
Isopentane	1.39e-002	3.35e-001
n-Pentane	2.13e-002	5.10e-001
Cyclopentane	3.62e-002	8.70e-001
n-Hexane	1.41e-002	3.38e-001
Cyclohexane	5.60e-002	1.35e+000
Other Hexanes	1.23e-002	2.96e-001
Heptanes	2.39e-002	5.75e-001
Methylcyclohexane	6.59e-002	1.58e+000
Benzene	6.08e-002	1.46e+000
Toluene	1.35e-001	3.23e+000
Ethylbenzene	1.93e-002	4.63e-001
Xylenes	1.71e-001	4.11e+000
C8+ Heavies	4.08e-002	9.79e-001
Total Components	100.00	2.40e+003

REGENERATOR OVERHEADS STREAM

Temperature: 212.00 deg. F
Pressure: 14.70 psia
Flow Rate: 1.84e+003 scfh

Component	Conc. (vol%)	Loading (lb/hr)
Water	9.44e+001	8.25e+001
Carbon Dioxide	8.23e-003	1.76e-002
Nitrogen	2.22e-002	3.02e-002
Methane	3.25e-001	2.53e-001
Ethane	5.52e-001	8.05e-001
Propane	7.22e-001	1.54e+000
Isobutane	1.46e-001	4.13e-001
n-Butane	4.93e-001	1.39e+000
Isopentane	9.44e-002	3.30e-001
n-Pentane	1.44e-001	5.04e-001
Cyclopentane	2.54e-001	8.64e-001
n-Hexane	8.02e-002	3.35e-001
Cyclohexane	3.17e-001	1.29e+000
Other Hexanes	6.95e-002	2.90e-001
Heptanes	1.17e-001	5.71e-001
Methylcyclohexane	3.17e-001	1.51e+000
Benzene	3.66e-001	1.39e+000

Toluene	6.66e-001	2.97e+000
Ethylbenzene	8.04e-002	4.14e-001
Xylenes	6.94e-001	3.57e+000
C8+ Heavies	1.04e-001	8.57e-001
---	---	---
Total Components	100.00	1.02e+002

2585 Heartland Dr.
Sheridan, WY 82801
Office: | Direct: +1 (307) 675.5081
riames@emittechnologies.com

Prepared For:
Doug Kern
EXTERRAN

QUOTE: QUO-18735-J1H7

INFORMATION PROVIDED BY CATERPILLAR

Engine:	G3516B
Horsepower:	1380
RPM:	1400
Compression Ratio:	8.0
Exhaust Flow Rate:	9143 CFM
Exhaust Temperature:	1014 ÁF
Reference:	EM1748-00-001
Fuel:	Natural Gas
Annual Operating Hours:	8760

Uncontrolled Emissions

	g/bhp-hr
NOx:	0.50
CO:	3.00
THC:	4.34
NMHC	1.78
NMNEHC:	1.03
HCHO:	0.39
O2:	9.10 %

POST CATALYST EMISSIONS

	g/bhp-hr
NOx:	Unaffected by Oxidation Catalyst
CO:	<0.17
VOC:	<0.45
HCHO:	<0.06

CONTROL EQUIPMENT

Catalyst Element

Model:	RT-2415-Z
Catalyst Type:	Oxidation, Standard Precious Group Metals
Substrate Type:	BRAZED
Manufacturer:	EMIT Technologies, Inc
Element Quantity:	3
Element Size:	Rectangle 24" x 15" x 3.5"

The information in this quotation, and any files transmitted with it, is confidential and may be legally privileged. It is intended only for the use of individual(s) within the company named above. If you are the intended recipient, be aware that your use of any confidential or personal information may be restricted by state and federal privacy laws

2585 Heartland Dr.
Sheridan, WY 82801
Office: | Direct: +1 (307) 675.5081
riames@emittechnologies.com

WARRANTY

EMIT Technologies, Inc. warrants that the goods supplied will be free from defects in workmanship by EMIT Technologies, Inc. for a period of two (2) years from date of shipment. EMIT Technologies, Inc. will not be responsible for any defects which result from improper use, neglect, failure to properly maintain or which are attributable to defects, errors or omissions in any drawings, specifications, plans or descriptions, whether written or oral, supplied to EMIT Technologies, Inc. by Buyer.

Catalyst performance using an EMIT Air/Fuel ratio controller is dependent upon properly defined set-points, variable with engine and fuel gas composition. Air/fuel ratio controller performance is guaranteed, but not limited, to fuel gas with a HHV content of 1400 BTU/SCF.

Catalyst performance will be guaranteed for a period of 1 year from installation, or 8760 operating hours, whichever comes first. The catalyst shall be operated with an automatic air/fuel ratio controller. The performance guarantee shall not cover the effects of excessive ash masking due to operation at low load, improper engine maintenance, or inappropriate lubrication oil. The performance guarantee shall not cover the effects of continuous engine misfires (cylinder or ignition) exposing the catalyst to excessive exothermic reaction temperatures. In most cases, excluding thermal deactivation, catalyst performance is redeemable by means of proper washing (refer to EMIT Catalyst/Silencer Housing Manual for element wash information, or contact a local EMIT Sales representative).

The exhaust temperature operating range at the converter inlet is a minimum of 600°F for oxidation catalyst and 750 ˚F for NSCR catalyst, and a maximum of 1250°F.

If a properly functioning, high temperature shut down switch is not installed, thermal deactivation of catalyst at sustained temperatures above 1250˚F is not covered. If excessive exposure to over oxygenation of NSCR catalyst occurs due to improperly functioning or non-existent Air/Fuel ratio control, then deactivation of catalyst is not warranted.

The catalyst conversion efficiencies (% reduction) will be guaranteed for engine loads of 50 to 100 percent. Standard Oxidation Catalyst conversion efficiencies (% reduction) will be guaranteed for fuel gas containing less than 1.5% mole fraction of non-methane, non-ethane hydrocarbons. Applications where fuel gas exceeds this level will require a Premium Oxidation Catalyst to maintain guaranteed VOC conversion efficiencies.

Engine lubrication oil shall contain less than 0.5 wt% Sulfated Ash with a maximum allowable specific oil consumption of 0.7 g/bhp-hr. The catalyst shall be limited to a maximum ash loading of 0.022 lb/ft3. Phosphorous and zinc additives are limited to 0.03 wt%. New or Reconstructed engines must operate for a minimum of 50 hours prior to catalyst installation, otherwise the warranty is void.

The catalyst must not be exposed to the following know poisoning agents, including: antimony, arsenic, chromium, copper, iron, lead, lithium, magnesium, mercury, nickel, phosphorous, potassium, silicon, sodium, sulfur, tin, and zinc. Total poison concentrations in the fuel gas must be limited to 0.25 ppm or less for catalyst to function properly.

Shipment - Promised shipping dates are approximate lead times from the point of manufacture and are not guaranteed. EMIT Technologies, Inc. will not be liable for any loss, damage or delay in manufacture or delivery resulting from any cause beyond its control including, but not limited to a period equal to the time lost by reason of that delay. All products will be crated as per best practice to prevent any damage during shipment. Unless otherwise specified, Buyer will pay for any special packing and shipping requirements. Acceptance of goods by common carrier constitutes delivery to Buyer. EMIT Technologies, Inc. shall not be responsible for goods damaged or lost in transit.

Terms: Credit is extended to purchaser for net 30 time period. If payment is not received in the net 30 timeframe, interest on the unpaid balance will accrue at a rate of 1.5% per month from the invoice date.

Order Cancellation Terms: Upon cancellation of an order once submittal of a Purchase Order has occurred, the customer will pay a 25% restocking fee for Catalyst Housings, Catalyst Elements, and Air/Fuel Ratio Controllers; 50% restocking fee for Cooler Top Solutions Exhaust System Accessories, and other Custom Built Products; 100% of all associated shipping costs incurred by EMIT; 100% of all project expenses incurred by EMIT for Field Services.

The information in this quotation, and any files transmitted with it, is confidential and may be legally privileged. It is intended only for the use of individual(s) within the company named above. If you are the intended recipient, be aware that your use of any confidential or personal information may be restricted by state and federal privacy laws

2585 Heartland Dr.
Sheridan, WY 82801
Office: | Direct: +1 (307) 675.5081
riames@emittechnologies.com

Prepared For:
Doug Kern
EXTERRAN

QUOTE: QUO-18456-X2L0

INFORMATION PROVIDED BY CATERPILLAR

Engine:	G3616
Horsepower:	5000
RPM:	1000
Compression Ratio:	7.6
Exhaust Flow Rate:	31338 CFM
Exhaust Temperature:	811 °F
Reference:	EM1426-02-001
Fuel:	Natural Gas
Annual Operating Hours:	8760

Uncontrolled Emissions

	g/bhp-hr	Lb/Hr	Tons/Year
NOx:	0.30	3.31	14.48
CO:	2.97	32.74	143.40
THC:	3.68	40.57	177.67
NMHC	1.51	16.64	72.90
NMNEHC:	0.87	9.59	42.00
HCHO:	0.14	1.54	6.76
O2:	11.10 %		

POST CATALYST EMISSIONS

	g/bhp-hr
NOx:	Unaffected by Oxidation Catalyst
CO:	<0.18
VOC:	<0.49
HCHO:	<0.03

CONTROL EQUIPMENT

Catalyst Element

Model:	RT-4815-Z
Catalyst Type:	Oxidation, Standard Precious Group Metals
Substrate Type:	BRAZED
Manufacturer:	EMIT Technologies, Inc
Element Quantity:	4
Element Size:	Rectangle 48" x 15" x 3.5"

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Sheridan, WY 82801
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WARRANTY

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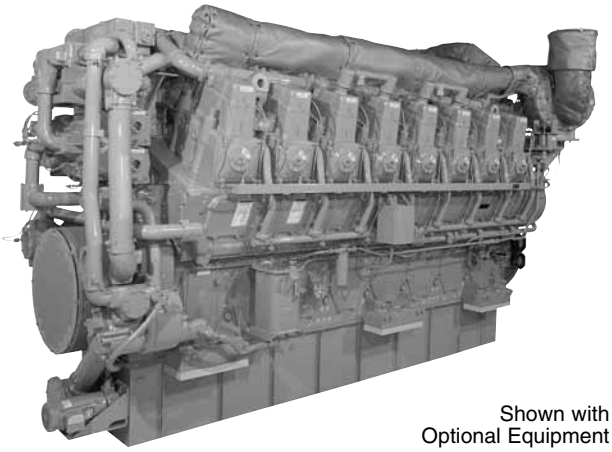
G3616 LE Gas Petroleum Engine

3531-3762 bkW (4735-5045 bhp) 1000 rpm



Shown with Optional Equipment

0.5 g/bhp-hr NOx or 0.7 g/bhp-hr NOx (NTE)

CAT® ENGINE SPECIFICATIONS

V-16, 4-Stroke-Cycle

Bore	300 mm (11.8 in.)
Stroke	300 mm (11.8 in.)
Displacement	339.18 L (20,698 cu. in.)
Aspiration	Turbocharged-Aftercooled
Digital Engine Management Governor and Protection	Electronic (ADEM™ A3)
Combustion	Low Emission (Lean Burn)
Engine Weight net dry (approx)	29,891 kg (65,900 lb)
Power Density	8.0 kg/kW (13.1 lb/hp)
Power per Displacement	14.9 bhp/L
Total Cooling System Capacity	972.9 L (257 gal)
Jacket Water	900.9 L (238 gal)
Aftercooler Circuit	71.9 L (19 gal)
Lube Oil System (refill)	1328.7 L (351 gal)
Oil Change Interval	5000 hours
Rotation (from flywheel end)	Counterclockwise
Flywheel Teeth	255

FEATURES

Engine Design
- Proven reliability and durability
- Ability to burn a wide spectrum of gaseous fuels
- Robust diesel strength design prolongs life and lowers owning and operating costs
- Broad operating speed range

Emissions
Meets U.S. EPA Spark Ignited Stationary NSPS Emissions for 2010/11 with the use of an oxidation catalyst

Lean Burn Engine Technology
Lean-burn engines operate with large amounts of excess air. The excess air absorbs heat during combustion reducing the combustion temperature and pressure, greatly reducing levels of NOx. Lean-burn design also provides longer component life and excellent fuel consumption.

Ease of Operation
- High-strength pan and rails for excellent mounting and stability
- Side covers on block allow for inspection of internal components

Advanced Digital Engine Management
ADEM A3 engine management system integrates speed control, air/fuel ratio control, and ignition/detonation controls into a complete engine management system. ADEM A3 has improved: user interface, display system, shutdown controls, and system diagnostics.

Full Range of Attachments
Large variety of factory-installed engine attachments reduces packaging time.

Testing
Every engine is full-load tested to ensure proper engine performance.

Gas Engine Rating Pro
GERP is a PC-based program designed to provide site performance capabilities for Cat® natural gas engines for the gas compression industry. GERP provides engine data for your site's altitude, ambient temperature, fuel, engine coolant heat rejection, performance data, installation drawings, spec sheets, and pump curves.

Product Support Offered Through Global Cat Dealer Network
More than 2,200 dealer outlets

Cat factory-trained dealer technicians service every aspect of your petroleum engine

Cat parts and labor warranty

Preventive maintenance agreements available for repair-before-failure options

S•O•S℠ program matches your oil and coolant samples against Caterpillar set standards to determine:
- Internal engine component condition
- Presence of unwanted fluids
- Presence of combustion by-products
- Site-specific oil change interval

Over 80 Years of Engine Manufacturing Experience
Over 60 years of natural gas engine production

Ownership of these manufacturing processes enables Caterpillar to produce high quality, dependable products
- Cast engine blocks, heads, cylinder liners, and flywheel housings
- Machine critical components
- Assemble complete engine

Web Site
For all your petroleum power requirements, visit www.catoilandgas.cat.com.

STANDARD EQUIPMENT

Air Inlet System
Air cleaner — standard duty
Inlet air adapter

Control System
A3 control system — provides electronic governing integrated with air/fuel ratio control and individual cylinder ignition timing control

Cooling System
Jacket water pump
Jacket water thermostats and housing
Aftercooler pump
Aftercooler water thermostats and housing
Single-stage aftercooler

Exhaust System
Dry wrapped exhaust manifolds
Vertical outlet adapter

Flywheel & Flywheel Housing
SAE standard rotation

Fuel System
Gas admission valves — electronically controlled fuel supply pressure

Ignition System
A3 control system — senses individual cylinder detonation and controls individual cylinder timing

Instrumentation
LCD display panel — monitors engine parameters and displays diagnostic codes

Lube System
Crankcase breathers — top mounted
Oil cooler
Oil filter
Oil pan drain valve

Mounting System
Engine mounting feet (six total)

Protection System
Electronic shutoff system with purge cycle
Crankcase explosion relief valves
Gas shutoff valve

Starting System
Air starting system

General
Paint — Cat yellow
Vibration dampers

OPTIONAL EQUIPMENT

Air Inlet System
Heavy-duty air cleaner with precleaners
Heavy-duty air cleaner with rain protection

Charging System
Charging alternators

Control System
Custom control system software — available for non-standard ratings, field programmable using flash memory

Cooling System
Expansion tank
Flexible connections
Jacket water heater

Exhaust System
Flexible bellows adapters
Exhaust expander
Weld flanges

Fuel System
Fuel filter
Gas pressure regulator
Flexible connection
Low energy fuel system
Corrosive gas fuel system

Ignition System
CSA certification

Instrumentation
Remote data monitoring and speed control
Compatible with Cat Electronic Technician (ET) and Data View
Communication Device — PL1000T/E
Display panel deletion is optional

Lube System
Air or electric motor-driven prelube
Duplex oil filter
LH or RH service
Lube oil makeup system

Mounting System
Mounting plates (set of six)

Power Take-Offs
Front stub shafts

Starting System
Air pressure reducing valve
Natural gas starting system

General
Engine barring device
Damper guard

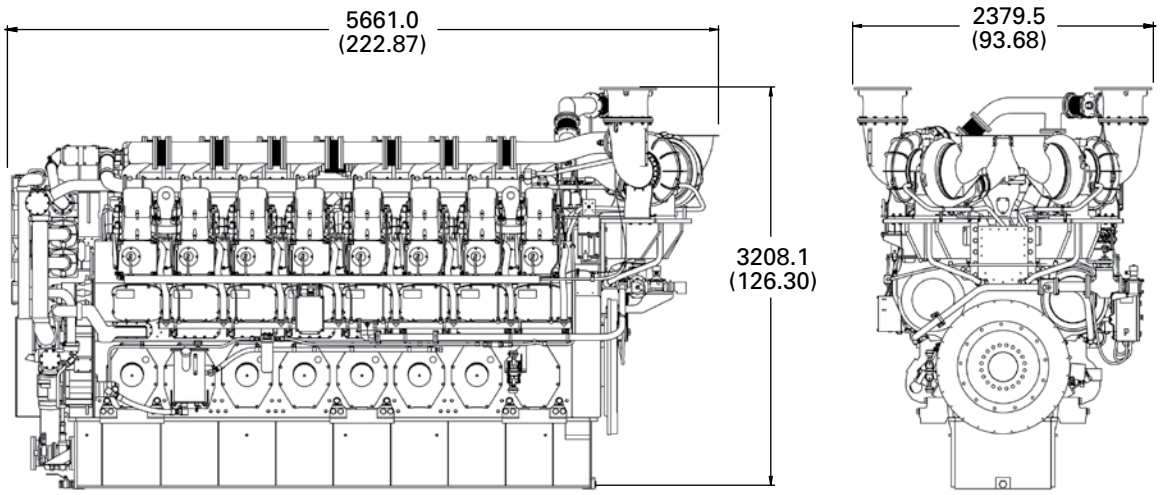
TECHNICAL DATA

G3616 LE Gas Petroleum Engine — 1000 rpm

		DM5133-03	DM5563-03	DM5564-03	DM8608-02
Engine Power					
@ 100% Load	bkW (bhp)	3646 (4890)	3531 (4735)	3762 (5045)	3531 (4735)
@ 75% Load	bkW (bhp)	2735 (3668)	2648 (3551)	2882 (3784)	2648 (3551)
Engine Speed	rpm	**1000**	**1000**	**1000**	**1000**
Max Altitude @ Rated Torque and 38°C (100°F)	m (ft)	1219.2 (4000)	609.6 (2000)	1219.2 (4000)	609.6 (2000)
Speed Turndown @ Max Altitude, Rated Torque, and 38°C (100°F)	%	20	24	20	24
SCAC Temperature	°C (°F)	43 (110)	54 (130)	32 (90)	54 (130)
Emissions*					
NOx	g/bkW-hr (g/bhp-hr)	.94 (0.7)	.94 (0.7)	.94 (0.7)	.67 (0.5)
CO	g/bkW-hr (g/bhp-hr)	3.4 (2.5)	3.4 (2.5)	3.4 (2.5)	3.7 (2.75)
CO_2	g/bkW-hr (g/bhp-hr)	585 (436)	587 (437)	583 (435)	589 (439)
VOC**	g/bkW-hr (g/bhp-hr)	0.78 (0.58)	0.81 (0.6)	0.76 (0.57)	0.85 (0.63)
Fuel Consumption***					
@ 100% Load	MJ/bkW-hr (Btu/bhp-hr)	9.28 (6556)	9.3 (6576)	9.25 (6537)	9.35 (6605)
@ 75% Load	MJ/bkW-hr (Btu/bhp-hr)	9.67 (6834)	9.71 (6863)	9.63 (6805)	9.75 (6893)
Heat Balance					
Heat Rejection to Jacket Water					
@ 100% Load	bkW (Btu/min)	869 (49,438)	842 (47,922)	894 (50,884)	842 (47,935)
@ 75% Load	bkW (Btu/min)	764 (43,434)	730 (41,488)	798 (45,348)	735 (41,766)
Heat Rejection to Aftercooler					
@ 100% Load	bkW (Btu/min)	660 (37,526)	578 (32,889)	744 (42,366)	602 (34,290)
@ 75% Load	bkW (Btu/min)	317 (18,044)	261 (14,841)	376 (21,397)	274 (15,569)
Heat Rejection to Exhaust LHV to 25°C (77° F)					
@ 100% Load	bkW (Btu/min)	3627 (206,280)	3596 (204,497)	3655 (207,837)	3609 (205,248)
@ 75% Load	bkW (Btu/min)	2927 (166,440)	2916 (165,846)	2933 (166,812)	2928 (166,501)
Exhaust System					
Exhaust Gas Flow Rate					
@ 100% Load	m^3/min (cfm)	913.87 (32,273)	898.35 (31,725)	928.85 (32,802)	908.97 (32,100)
@ 75% Load	m^3/min (cfm)	726.21 (25,646)	716.90 (25,317)	734.94 (25,954)	725.36 (25,616)
Exhaust Stack Temperature					
@ 100% Load	°C (°F)	461 (862)	469 (876)	453 (847)	458 (856)
@ 75% Load	°C (°F)	481 (898)	492 (918)	469 (877)	481 (897)
Intake System					
Air Inlet Flow Rate					
@ 100% Load	m^3/min (scfm)	348.10 (12,293)	338.47 (11,953)	357.73 (12,633)	348.13 (12,294)
@ 75% Load	m^3/min (scfm)	269.12 (9504)	261.76 (9244)	276.49 (9764)	269.21 (9507)
Gas Pressure	kPag (psig)	295-324 (42.8-47)	295-324 (42.8-47)	295-324 (42.8-47)	295-324 (42.8-47)

*at 100% load and speed, all values are listed as not to exceed
**Volatile organic compounds as defined in U.S. EPA 40 CFR 60, subpart JJJJ
***ISO 3046/1

GAS PETROLEUM ENGINE



DIMENSIONS		
Length	mm (in)	5661.0 (222.87)
Width	mm (in)	2379.5 (93.68)
Height	mm (in)	3208.1 (126.30)
Shipping Weight	kg (lb)	29,891 (65,900)

Note: General configuration not to be used for installation. See general dimension drawing number 246-1515 for detail.

RATING DEFINITIONS AND CONDITIONS

Engine performance is obtained in accordance with SAE J1995, ISO3046/1, BS5514/1, and DIN6271/1 standards.

Transient response data is acquired from an engine/generator combination at normal operating temperature and in accordance with ISO3046/1 standard ambient conditions. Also in accordance with SAE J1995, BS5514/1, and DIN6271/1 standard reference conditions.

Conditions: Power for gas engines is based on fuel having an LHV of 33.74 kJ/L (905 Btu/cu ft) at 101 kPa (29.91 in. Hg) and 15° C (59° F). Fuel rate is based on a cubic meter at 100 kPa (29.61 in. Hg) and 15.6° C (60.1° F). Air flow is based on a cubic foot at 100 kPa (29.61 in. Hg) and 25° C (77° F). Exhaust flow is based on a cubic foot at 100 kPa (29.61 in. Hg) and stack temperature.

Materials and specifications are subject to change without notice. The International System of Units (SI) is used in this publication.
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February 3, 2016

FESCO, Ltd.
1100 Fesco Ave. - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Sample: Cotton Hills CTB
Meter Run Gas
Sampled @ 171 psig & 86 °F

Date Sampled: 01/19/16 Job Number: 61194.051

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2286

COMPONENT	MOL%	GPM
Hydrogen Sulfide*	< 0.001	
Nitrogen	0.837	
Carbon Dioxide	0.075	
Methane	77.739	
Ethane	12.345	3.367
Propane	5.540	1.556
Isobutane	0.673	0.225
n-Butane	1.482	0.476
2-2 Dimethylpropane	0.004	0.002
Isopentane	0.283	0.106
n-Pentane	0.326	0.121
Hexanes	0.306	0.129
Heptanes Plus	0.390	0.167
Totals	100.000	6.148

Computed Real Characteristics Of Heptanes Plus:

Specific Gravity	3.453	(Air=1)
Molecular Weight	99.64	
Gross Heating Value	5313	BTU/CF

Computed Real Characteristics Of Total Sample:

Specific Gravity	0.736	(Air=1)
Compressibility (Z)	0.9962	
Molecular Weight	21.24	
Gross Heating Value		
Dry Basis	1306	BTU/CF
Saturated Basis	1284	BTU/CF

*Hydrogen Sulfide tested on location by: Stain Tube Method (GPA 2377)
Results: 0.047 Gr/100 CF, 0.8 PPMV or <0.0001 Mol%

Base Conditions: 15.025 PSI & 60 Deg F

Sampled By: (24) A. Fin
Analyst: MR
Processor: OA
Cylinder ID: T-4119

Certified: FESCO, Ltd. - Alice, Texas

David Dannhaus 361-661-7015

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2286
TOTAL REPORT

COMPONENT	MOL %	GPM	WT %
Hydrogen Sulfide*	< 0.001		< 0.001
Nitrogen	0.837		1.104
Carbon Dioxide	0.075		0.155
Methane	77.739		58.715
Ethane	12.345	3.367	17.476
Propane	5.540	1.556	11.501
Isobutane	0.673	0.225	1.842
n-Butane	1.482	0.476	4.055
2,2 Dimethylpropane	0.004	0.002	0.014
Isopentane	0.283	0.106	0.961
n-Pentane	0.326	0.121	1.107
2,2 Dimethylbutane	0.005	0.002	0.020
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.029	0.012	0.118
2 Methylpentane	0.094	0.040	0.381
3 Methylpentane	0.050	0.021	0.203
n-Hexane	0.128	0.054	0.519
Methylcyclopentane	0.051	0.018	0.202
Benzene	0.007	0.002	0.026
Cyclohexane	0.054	0.019	0.214
2-Methylhexane	0.016	0.008	0.075
3-Methylhexane	0.018	0.008	0.085
2,2,4 Trimethylpentane	0.000	0.000	0.000
Other C7's	0.047	0.021	0.219
n-Heptane	0.038	0.018	0.179
Methylcyclohexane	0.050	0.020	0.231
Toluene	0.011	0.004	0.048
Other C8's	0.044	0.021	0.228
n-Octane	0.013	0.007	0.070
Ethylbenzene	0.001	0.000	0.005
M & P Xylenes	0.006	0.002	0.030
O-Xylene	0.001	0.000	0.005
Other C9's	0.015	0.008	0.089
n-Nonane	0.003	0.002	0.018
Other C10's	0.004	0.002	0.027
n-Decane	0.002	0.001	0.013
Undecanes (11)	0.009	0.006	0.065
Totals	100.000	6.148	100.000

Computed Real Characteristics of Total Sample

Specific Gravity	0.736	(Air=1)
Compressibility (Z)	0.9962	
Molecular Weight	21.24	

Gross Heating Value

Dry Basis	1306	BTU/CF
Saturated Basis	1284	BTU/CF

FESCO, Ltd.
1100 Fesco Ave. - Alice, Texas 78332

Sample: Cotton Hills CTB
Meter Run Gas
Sampled @ 171 psig & 86 °F

Date Sampled: 01/19/16 Job Number: 61194.051

GLYCALC FORMAT

COMPONENT	MOL%	GPM	Wt %
Carbon Dioxide	0.075		0.155
Hydrogen Sulfide	< 0.001		< 0.001
Nitrogen	0.837		1.104
Methane	77.739		58.715
Ethane	12.345	3.367	17.476
Propane	5.540	1.556	11.501
Isobutane	0.673	0.225	1.842
n-Butane	1.486	0.478	4.069
Isopentane	0.283	0.106	0.961
n-Pentane	0.326	0.121	1.107
Cyclopentane	0.000	0.000	0.000
n-Hexane	0.128	0.054	0.519
Cyclohexane	0.054	0.019	0.214
Other C6's	0.178	0.075	0.722
Heptanes	0.170	0.073	0.760
Methylcyclohexane	0.050	0.020	0.231
2,2,4 Trimethylpentane	0.000	0.000	0.000
Benzene	0.007	0.002	0.026
Toluene	0.011	0.004	0.048
Ethylbenzene	0.001	0.000	0.005
Xylenes	0.007	0.003	0.035
Octanes Plus	0.090	0.046	0.510
Totals	100.000	6.148	100.000

Real Characteristics Of Octanes Plus:

Specific Gravity	4.170	(Air=1)
Molecular Weight	120.31	
Gross Heating Value	6389	BTU/CF

Real Characteristics Of Total Sample:

Specific Gravity	0.736	(Air=1)
Compressibility (Z)	0.9962	
Molecular Weight	21.24	
Gross Heating Value		
Dry Basis	1306	BTU/CF
Saturated Basis	1284	BTU/CF

February 10, 2016

FESCO, Ltd.
1100 FESCO Avenue - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Sample: Cotton Hills CTB
Separator Hydrocarbon Liquid
Sampled @ 169 psig & 90 °F

Date Sampled: 01/19/16 Job Number: 61194.012

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2186-M

COMPONENT	MOL %	LIQ VOL %	WT %
Nitrogen	0.024	0.005	0.005
Carbon Dioxide	0.013	0.004	0.004
Methane	4.462	1.411	0.569
Ethane	5.193	2.592	1.242
Propane	8.565	4.404	3.003
Isobutane	2.348	1.434	1.085
n-Butane	7.403	4.356	3.422
2,2 Dimethylpropane	0.056	0.040	0.032
Isopentane	3.272	2.233	1.877
n-Pentane	4.641	3.140	2.663
2,2 Dimethylbutane	0.058	0.046	0.040
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.312	0.238	0.214
2 Methylpentane	1.588	1.231	1.089
3 Methylpentane	0.893	0.680	0.612
n-Hexane	2.753	2.113	1.886
Heptanes Plus	58.418	76.074	82.257
Totals:	100.000	100.000	100.000

Characteristics of Heptanes Plus:

Specific Gravity	0.8041	(Water=1)
°API Gravity	44.46	@ 60°F
Molecular Weight	177.1	
Vapor Volume	14.41	CF/Gal
Weight	6.70	Lbs/Gal

Characteristics of Total Sample:

Specific Gravity	0.7437	(Water=1)
°API Gravity	58.76	@ 60°F
Molecular Weight	125.8	
Vapor Volume	18.77	CF/Gal
Weight	6.20	Lbs/Gal

Base Conditions: 15.025 PSI & 60 °F

Certified: FESCO, Ltd. - Alice, Texas

Sampled By: (24) Finn
Analyst: XG
Processor: XG
Cylinder ID: W-1850

David Dannhaus 361-661-7015

TANKS DATA INPUT REPORT - GPA 2186-M

COMPONENT	Mol %	LiqVol %	Wt %
Carbon Dioxide	0.013	0.004	0.004
Nitrogen	0.024	0.005	0.005
Methane	4.462	1.411	0.569
Ethane	5.193	2.592	1.242
Propane	8.565	4.404	3.003
Isobutane	2.348	1.434	1.085
n-Butane	7.459	4.396	3.454
Isopentane	3.272	2.233	1.877
n-Pentane	4.641	3.140	2.663
Other C-6's	2.851	2.195	1.954
Heptanes	9.179	7.145	6.878
Octanes	10.333	8.791	8.747
Nonanes	5.042	5.119	5.085
Decanes Plus	31.561	53.461	59.716
Benzene	0.186	0.097	0.116
Toluene	0.643	0.402	0.471
E-Benzene	0.195	0.141	0.165
Xylenes	1.278	0.919	1.079
n-Hexane	2.753	2.113	1.886
2,2,4 Trimethylpentane	0.000	0.000	0.000
Totals:	100.000	100.000	100.000

Characteristics of Total Sample:

Specific Gravity	0.7437	(Water=1)
°API Gravity	58.76	@ 60°F
Molecular Weight	125.8	
Vapor Volume	18.77	CF/Gal
Weight	6.20	Lbs/Gal

Characteristics of Decanes (C10) Plus:

Specific Gravity	0.8307	(Water=1)
Molecular Weight	237.9	

Characteristics of Atmospheric Sample:

°API Gravity	50.52	@ 60°F
Reid Vapor Pressure Equivalent (D-6377)	6.20	psi

QUALITY CONTROL CHECK			
	Sampling Conditions	Test Samples	
Cylinder Number	------	W-1850*	W-890
Pressure, PSIG	169	170	171
Temperature, °F	90	70	70

* Sample used for analysis

TOTAL EXTENDED REPORT - GPA 2186-M

COMPONENT	Mol %	LiqVol %	Wt %
Nitrogen	0.024	0.005	0.005
Carbon Dioxide	0.013	0.004	0.004
Methane	4.462	1.411	0.569
Ethane	5.193	2.592	1.242
Propane	8.565	4.404	3.003
Isobutane	2.348	1.434	1.085
n-Butane	7.403	4.356	3.422
2,2 Dimethylpropane	0.056	0.040	0.032
Isopentane	3.272	2.233	1.877
n-Pentane	4.641	3.140	2.663
2,2 Dimethylbutane	0.058	0.046	0.040
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.312	0.238	0.214
2 Methylpentane	1.588	1.231	1.089
3 Methylpentane	0.893	0.680	0.612
n-Hexane	2.753	2.113	1.886
Methylcyclopentane	1.467	0.969	0.982
Benzene	0.186	0.097	0.116
Cyclohexane	1.842	1.170	1.233
2-Methylhexane	0.898	0.779	0.715
3-Methylhexane	0.845	0.724	0.674
2,2,4 Trimethylpentane	0.000	0.000	0.000
Other C-7's	1.782	1.484	1.406
n-Heptane	2.346	2.020	1.869
Methylcyclohexane	3.233	2.425	2.524
Toluene	0.643	0.402	0.471
Other C-8's	7.100	6.366	6.223
n-Octane	0.000	0.000	0.000
E-Benzene	0.195	0.141	0.165
M & P Xylenes	0.787	0.570	0.664
O-Xylene	0.492	0.349	0.415
Other C-9's	3.610	3.615	3.624
n-Nonane	1.432	1.504	1.460
Other C-10's	3.759	4.136	4.223
n-decane	0.935	1.072	1.058
Undecanes(11)	3.797	4.287	4.438
Dodecanes(12)	2.847	3.472	3.645
Tridecanes(13)	2.779	3.633	3.867
Tetradecanes(14)	2.275	3.186	3.437
Pentadecanes(15)	2.073	3.110	3.395
Hexadecanes(16)	1.446	2.318	2.552
Heptadecanes(17)	1.365	2.315	2.573
Octadecanes(18)	1.109	1.979	2.213
Nonadecanes(19)	1.137	2.114	2.377
Eicosanes(20)	0.879	1.699	1.922
Heneicosanes(21)	0.777	1.581	1.799
Docosanes(22)	0.719	1.525	1.745
Tricosanes(23)	0.580	1.274	1.466
Tetracosanes(24)	0.554	1.261	1.458
Pentacosanes(25)	0.477	1.126	1.307
Hexacosanes(26)	0.347	0.848	0.990
Heptacosanes(27)	0.444	1.127	1.321
Octacosanes(28)	0.339	0.890	1.046
Nonacosanes(29)	0.272	0.738	0.871
Triacontanes(30)	0.241	0.674	0.797
Hentriacontanes Plus(31+)	2.411	9.097	11.216
Total	100.000	100.000	100.000

February 10, 2016

FESCO, Ltd.
1100 FESCO Avenue - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Sample: Cotton Hills CTB
Heater Treater Hydrocarbon Liquid
Sampled @ 25 psig & 76 °F

Date Sampled: 01/19/16 Job Number: 61194.002

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2186-M

COMPONENT	MOL %	LIQ VOL %	WT %
Nitrogen	0.016	0.003	0.003
Carbon Dioxide	0.000	0.000	0.000
Methane	0.418	0.124	0.049
Ethane	2.581	1.207	0.566
Propane	7.094	3.418	2.283
Isobutane	2.291	1.311	0.972
n-Butane	7.469	4.118	3.168
2,2 Dimethylpropane	0.069	0.046	0.036
Isopentane	3.507	2.243	1.846
n-Pentane	5.027	3.187	2.647
2,2 Dimethylbutane	0.067	0.049	0.042
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.374	0.268	0.235
2 Methylpentane	1.783	1.294	1.121
3 Methylpentane	1.008	0.720	0.634
n-Hexane	3.100	2.230	1.949
Heptanes Plus	65.196	79.782	84.449
Totals:	100.000	100.000	100.000

Characteristics of Heptanes Plus:

Specific Gravity	0.8040	(Water=1)
°API Gravity	44.51	@ 60°F
Molecular Weight	177.5	
Vapor Volume	14.37	CF/Gal
Weight	6.70	Lbs/Gal

Characteristics of Total Sample:

Specific Gravity	0.7595	(Water=1)
°API Gravity	54.80	@ 60°F
Molecular Weight	137.0	
Vapor Volume	17.59	CF/Gal
Weight	6.33	Lbs/Gal

Base Conditions: 15.025 PSI & 60 °F

Certified: FESCO, Ltd. - Alice, Texas

Sampled By: (24) Finn
Analyst: XG
Processor: XGdjv
Cylinder ID: W-2341

David Dannhaus 361-661-7015

TANKS DATA INPUT REPORT - GPA 2186-M

COMPONENT	Mol %	LiqVol %	Wt %
Carbon Dioxide	0.000	0.000	0.000
Nitrogen	0.016	0.003	0.003
Methane	0.418	0.124	0.049
Ethane	2.581	1.207	0.566
Propane	7.094	3.418	2.283
Isobutane	2.291	1.311	0.972
n-Butane	7.538	4.164	3.204
Isopentane	3.507	2.243	1.846
n-Pentane	5.027	3.187	2.647
Other C-6's	3.232	2.331	2.032
Heptanes	10.247	7.472	7.043
Octanes	11.474	9.259	8.971
Nonanes	5.673	5.397	5.250
Decanes Plus	35.226	56.020	61.307
Benzene	0.210	0.103	0.120
Toluene	0.721	0.422	0.485
E-Benzene	0.218	0.147	0.169
Xylenes	1.427	0.961	1.105
n-Hexane	3.100	2.230	1.949
2,2,4 Trimethylpentane	0.000	0.000	0.000
Totals:	100.000	100.000	100.000

Characteristics of Total Sample:

Specific Gravity	0.7595	(Water=1)
°API Gravity	54.80	@ 60°F
Molecular Weight	137.0	
Vapor Volume	17.59	CF/Gal
Weight	6.33	Lbs/Gal

Characteristics of Decanes (C10) Plus:

Specific Gravity	0.8312	(Water=1)
Molecular Weight	238.5	

Characteristics of Atmospheric Sample:

°API Gravity	50.83	@ 60°F
Reid Vapor Pressure Equivalent (D-6377)	9.07	psi

QUALITY CONTROL CHECK			
	Sampling Conditions	Test Samples	
Cylinder Number	------	W-2341*	W-2514
Pressure, PSIG	25	26	27
Temperature, °F	76	70	70

* Sample used for analysis

TOTAL EXTENDED REPORT - GPA 2186-M

COMPONENT	Mol %	LiqVol %	Wt %
Nitrogen	0.016	0.003	0.003
Carbon Dioxide	0.000	0.000	0.000
Methane	0.418	0.124	0.049
Ethane	2.581	1.207	0.566
Propane	7.094	3.418	2.283
Isobutane	2.291	1.311	0.972
n-Butane	7.469	4.118	3.168
2,2 Dimethylpropane	0.069	0.046	0.036
Isopentane	3.507	2.243	1.846
n-Pentane	5.027	3.187	2.647
2,2 Dimethylbutane	0.067	0.049	0.042
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.374	0.268	0.235
2 Methylpentane	1.783	1.294	1.121
3 Methylpentane	1.008	0.720	0.634
n-Hexane	3.100	2.230	1.949
Methylcyclopentane	1.645	1.018	1.010
Benzene	0.210	0.103	0.120
Cyclohexane	2.064	1.229	1.267
2-Methylhexane	1.000	0.813	0.731
3-Methylhexane	0.941	0.755	0.688
2,2,4 Trimethylpentane	0.000	0.000	0.000
Other C-7's	1.986	1.549	1.437
n-Heptane	2.611	2.107	1.909
Methylcyclohexane	3.619	2.544	2.592
Toluene	0.721	0.422	0.485
Other C-8's	5.780	4.855	4.648
n-Octane	2.076	1.860	1.730
E-Benzene	0.218	0.147	0.169
M & P Xylenes	0.875	0.594	0.678
O-Xylene	0.552	0.367	0.428
Other C-9's	4.068	3.817	3.747
n-Nonane	1.606	1.580	1.503
Other C-10's	4.233	4.365	4.364
n-decane	1.048	1.125	1.088
Undecanes(11)	4.330	4.581	4.644
Dodecanes(12)	3.190	3.646	3.748
Tridecanes(13)	3.137	3.844	4.006
Tetradecanes(14)	2.560	3.360	3.549
Pentadecanes(15)	2.282	3.209	3.431
Hexadecanes(16)	1.551	2.331	2.513
Heptadecanes(17)	1.527	2.426	2.641
Octadecanes(18)	1.244	2.081	2.278
Nonadecanes(19)	1.268	2.209	2.433
Eicosanes(20)	0.972	1.760	1.950
Heneicosanes(21)	0.796	1.517	1.691
Docosanes(22)	0.748	1.486	1.665
Tricosanes(23)	0.616	1.269	1.430
Tetracosanes(24)	0.565	1.206	1.365
Pentacosanes(25)	0.500	1.106	1.258
Hexacosanes(26)	0.382	0.875	1.000
Heptacosanes(27)	0.485	1.154	1.324
Octacosanes(28)	0.342	0.842	0.969
Nonacosanes(29)	0.299	0.759	0.877
Triacontanes(30)	0.290	0.759	0.880
Hentriacontanes Plus(31+)	2.859	10.108	12.204
Total	100.000	100.000	100.000

January 29, 2016

FESCO, Ltd.
1100 Fesco Avenue - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Date Sampled: 01/19/16

Date Analyzed: 01/28/16

Job Number: J61194

Sample: Cotton Hills CTB

FLASH LIBERATION OF HYDROCARBON LIQUID				
	1st Stage Separator	2nd Stage Separator	Stock Tank	Total
Pressure, psig	169	25	0	------
Temperature, °F	90	76	70	------
Gas Oil Ratio (1)	------	78	76	154
Gas Specific Gravity (2)	------	1.065	1.605	------
Separator Volume Factor (3)	1.1083	------	1.000	------

STOCK TANK FLUID PROPERTIES	
Shrinkage Recovery Factor (4)	0.9023
Oil API Gravity at 60 °F	50.52
Reid Vapor Pressure Equivalent (D-6377), psi (5)	6.20

QUALITY CONTROL CHECK			
	Sampling Conditions	Test Samples	
Cylinder Number	------	W-1850*	W-890
Pressure, psig	169	170	171
Temperature, °F	90	70	70

(1) - Scf of flashed vapor per barrel of stock tank oil
(2) - Air = 1.000
(3) - Separator volume / Stock tank volume
(4) - Fraction of first stage liquid
(5) - Absolute pressure at 100 deg F
Analyst: E.F.
* Sample used for flash study.

Base Conditions: 15.025 psia at 60 °F

Certified: FESCO, Ltd. - Alice, Texas

David Dannhaus 361-661-7015

January 29, 2016

FESCO, Ltd.
1100 Fesco Ave. - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Sample: Cotton Hills CTB
Gas Evolved from Hydrocarbon Liquid Flashed
From 169 psig & 90 °F to 25 psig & 76 °F

Date Sampled: 01/19/16 Job Number: 61194.001

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2286

COMPONENT	MOL%	GPM
Hydrogen Sulfide*	< 0.001	
Nitrogen	0.090	
Carbon Dioxide	0.079	
Methane	42.327	
Ethane	27.303	7.446
Propane	19.122	5.372
Isobutane	2.492	0.832
n-Butane	5.481	1.762
2-2 Dimethylpropane	0.000	0.000
Isopentane	0.966	0.360
n-Pentane	1.017	0.376
Hexanes	0.592	0.249
Heptanes Plus	0.531	0.220
Totals	100.000	16.617

Computed Real Characteristics Of Heptanes Plus:

Specific Gravity	3.351	(Air=1)
Molecular Weight	96.24	
Gross Heating Value	5120	BTU/CF

Computed Real Characteristics Of Total Sample:

Specific Gravity	1.065	(Air=1)
Compressibility (Z)	0.9914	
Molecular Weight	30.58	
Gross Heating Value		
Dry Basis	1842	BTU/CF
Saturated Basis	1810	BTU/CF

*Hydrogen Sulfide tested in laboratory by: Stain Tube Method (GPA 2377)
Results: <0.013 Gr/100 CF, <0.2 PPMV or <0.001 Mol %

Base Conditions: 15.025 PSI & 60 Deg F

Sampled By: (16) Franco
Analyst: MR
Processor: AS
Cylinder ID: EF-9

Certified: FESCO, Ltd. - Alice, Texas

David Dannhaus 361-661-7015

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2286
TOTAL REPORT

COMPONENT	MOL %	GPM	WT %
Hydrogen Sulfide*	< 0.001		< 0.001
Nitrogen	0.090		0.082
Carbon Dioxide	0.079		0.114
Methane	42.327		22.206
Ethane	27.303	7.446	26.848
Propane	19.122	5.372	27.575
Isobutane	2.492	0.832	4.737
n-Butane	5.481	1.762	10.418
2,2 Dimethylpropane	0.000	0.000	0.000
Isopentane	0.966	0.360	2.279
n-Pentane	1.017	0.376	2.400
2,2 Dimethylbutane	0.011	0.005	0.031
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.057	0.024	0.161
2 Methylpentane	0.183	0.077	0.516
3 Methylpentane	0.098	0.041	0.276
n-Hexane	0.243	0.102	0.685
Methylcyclopentane	0.091	0.032	0.250
Benzene	0.011	0.003	0.028
Cyclohexane	0.089	0.031	0.245
2-Methylhexane	0.025	0.012	0.082
3-Methylhexane	0.026	0.012	0.085
2,2,4 Trimethylpentane	0.000	0.000	0.000
Other C7's	0.072	0.032	0.234
n-Heptane	0.053	0.025	0.174
Methylcyclohexane	0.065	0.027	0.209
Toluene	0.013	0.004	0.039
Other C8's	0.049	0.023	0.177
n-Octane	0.012	0.006	0.045
Ethylbenzene	0.000	0.000	0.000
M & P Xylenes	0.004	0.002	0.014
O-Xylene	0.001	0.000	0.003
Other C9's	0.012	0.006	0.050
n-Nonane	0.002	0.001	0.008
Other C10's	0.002	0.001	0.009
n-Decane	0.001	0.001	0.005
Undecanes (11)	0.003	0.002	0.015
Totals	100.000	16.617	100.000

Computed Real Characteristics Of Total Sample:

Specific Gravity	1.065	(Air=1)
Compressibility (Z)	0.9914	
Molecular Weight	30.58	
Gross Heating Value		
Dry Basis	1842	BTU/CF
Saturated Basis	1810	BTU/CF

January 29, 2016

FESCO, Ltd.
1100 Fesco Ave. - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Sample: Cotton Hills CTB
Gas Evolved from Hydrocarbon Liquid Flashed
From 25 psig & 76 °F to 0 psig & 70 °F

Date Sampled: 01/19/16 Job Number: 61194.011

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2286

COMPONENT	MOL%	GPM
Hydrogen Sulfide*	< 0.001	
Nitrogen	0.000	
Carbon Dioxide	0.030	
Methane	7.082	
Ethane	24.046	6.558
Propane	36.454	10.242
Isobutane	6.526	2.178
n-Butane	15.395	4.949
2-2 Dimethylpropane	0.057	0.022
Isopentane	3.097	1.155
n-Pentane	3.310	1.224
Hexanes	1.980	0.832
Heptanes Plus	2.023	0.851
Totals	100.000	28.010

Computed Real Characteristics Of Heptanes Plus:

Specific Gravity	3.437	(Air=1)
Molecular Weight	97.52	
Gross Heating Value	5190	BTU/CF

Computed Real Characteristics Of Total Sample:

Specific Gravity	1.605	(Air=1)
Compressibility (Z)	0.9797	
Molecular Weight	45.54	
Gross Heating Value		
Dry Basis	2697	BTU/CF
Saturated Basis	2651	BTU/CF

*Hydrogen Sulfide tested in laboratory by: Stain Tube Method (GPA 2377)
Results: <0.013 Gr/100 CF, <0.2 PPMV or <0.001 Mol %

Base Conditions: 15.025 PSI & 60 Deg F

Sampled By: (16) Franco
Analyst: MR
Processor: AS
Cylinder ID: EF-1

Certified: FESCO, Ltd. - Alice, Texas

David Dannhaus 361-661-7015

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2286
TOTAL REPORT

COMPONENT	MOL %	GPM	WT %
Hydrogen Sulfide*	< 0.001		< 0.001
Nitrogen	0.000		0.000
Carbon Dioxide	0.030		0.029
Methane	7.082		2.499
Ethane	24.046	6.558	15.878
Propane	36.454	10.242	35.299
Isobutane	6.526	2.178	8.329
n-Butane	15.395	4.949	19.649
2,2 Dimethylpropane	0.057	0.022	0.090
Isopentane	3.097	1.155	4.907
n-Pentane	3.310	1.224	5.244
2,2 Dimethylbutane	0.033	0.014	0.062
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.181	0.076	0.343
2 Methylpentane	0.589	0.249	1.115
3 Methylpentane	0.304	0.127	0.575
n-Hexane	0.873	0.366	1.652
Methylcyclopentane	0.305	0.107	0.564
Benzene	0.037	0.011	0.063
Cyclohexane	0.306	0.106	0.565
2-Methylhexane	0.089	0.042	0.196
3-Methylhexane	0.097	0.045	0.213
2,2,4 Trimethylpentane	0.000	0.000	0.000
Other C7's	0.258	0.114	0.562
n-Heptane	0.205	0.096	0.451
Methylcyclohexane	0.270	0.111	0.582
Toluene	0.046	0.016	0.093
Other C8's	0.220	0.104	0.532
n-Octane	0.061	0.032	0.153
Ethylbenzene	0.004	0.002	0.009
M & P Xylenes	0.018	0.007	0.042
O-Xylene	0.004	0.002	0.009
Other C9's	0.072	0.037	0.200
n-Nonane	0.003	0.002	0.008
Other C10's	0.023	0.014	0.071
n-Decane	0.001	0.001	0.003
Undecanes (11)	0.004	0.003	0.013
Totals	100.000	28.010	100.000

Computed Real Characteristics Of Total Sample:

Specific Gravity	1.605	(Air=1)
Compressibility (Z)	0.9797	
Molecular Weight	45.54	
Gross Heating Value		
Dry Basis	2697	BTU/CF
Saturated Basis	2651	BTU/CF

February 10, 2016

FESCO, Ltd.
1100 Fesco Avenue - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Date Sampled: 01/19/16

Date Analyzed: 01/26/16

Job Number: J61194

Sample: Cotton Hills CTB

FLASH LIBERATION OF SEPARATOR WATER		
	Separator	Stock Tank
Pressure, psig	175	0
Temperature, °F	74	70
Gas Water Ratio (1)	------	0.84
Gas Specific Gravity (2)	------	0.735

(1) - Scf of water saturated vapor per barrel of stock tank water
(2) - Air = 1.000
(3) - Separator volume / Stock tank volume
Analyst: T.G.

Piston No.: PW-37699

Base Conditions: 15.025 PSI & 60 °F

Certified: FESCO, Ltd. - Alice, Texas

David Dannhaus 361-661-7015

February 3, 2016

FESCO, Ltd.
1100 Fesco Ave. - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Sample: Cotton Hills CTB
Gas Liberated From Separator Water
From 175 psig & 74 °F to 0 psig & 70 °F

Date Sampled: 01/19/16 Job Number: 61194.031

CHROMATOGRAPH EXTENDED ANALYSIS - SUMMATION REPORT - GPA 2286

COMPONENT	MOL%	GPM
Hydrogen Sulfide*	< 0.001	
Nitrogen	0.217	
Carbon Dioxide	1.768	
Methane	74.541	
Ethane	16.472	4.492
Propane	5.251	1.475
Isobutane	0.322	0.107
n-Butane	0.892	0.287
2-2 Dimethylpropane	0.000	0.000
Isopentane	0.098	0.037
n-Pentane	0.111	0.041
Hexanes	0.065	0.027
Heptanes Plus	0.262	0.093
Totals	100.000	6.560

Computed Real Characteristics Of Heptanes Plus:

Specific Gravity	3.117	(Air=1)
Molecular Weight	89.95	
Gross Heating Value	4552	BTU/CF

Computed Real Characteristics Of Total Sample:

Specific Gravity	0.735	(Air=1)
Compressibility (Z)	0.9963	
Molecular Weight	21.21	
Gross Heating Value		
Dry Basis	1272	BTU/CF
Saturated Basis	1250	BTU/CF

*Hydrogen Sulfide tested in laboratory by: Stained Tube Method (GPA 2377)
Results: 0.252 Gr/100 CF, 4.0 PPMV or 0.0004 Mol %

Base Conditions: 15.025 PSI & 60 Deg F

Sampled By: (16) T. Gonzalez
Analyst: HB
Processor: OA
Cylinder ID: WF# 6S

Certified: FESCO, Ltd. - Alice, Texas

David Dannhaus 361-661-7015

CHROMATOGRAPH EXTENDED ANALYSIS
TOTAL REPORT - GPA 2286

COMPONENT	MOL %	GPM	WT %
Hydrogen Sulfide*	< 0.001		0.001
Nitrogen	0.217		0.287
Carbon Dioxide	1.768		3.668
Methane	74.541		56.370
Ethane	16.472	4.492	23.348
Propane	5.251	1.475	10.914
Isobutane	0.322	0.107	0.881
n-Butane	0.892	0.287	2.443
2,2 Dimethylpropane	0.000	0.000	0.000
Isopentane	0.098	0.037	0.335
n-Pentane	0.111	0.041	0.379
2,2 Dimethylbutane	0.000	0.000	0.000
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.024	0.010	0.097
2 Methylpentane	0.013	0.006	0.054
3 Methylpentane	0.008	0.003	0.034
n-Hexane	0.019	0.008	0.079
Methylcyclopentane	0.029	0.010	0.114
Benzene	0.059	0.017	0.216
Cyclohexane	0.045	0.016	0.180
2-Methylhexane	0.000	0.000	0.000
3-Methylhexane	0.004	0.002	0.019
2,2,4 Trimethylpentane	0.000	0.000	0.000
Other C7's	0.004	0.002	0.019
n-Heptane	0.007	0.003	0.033
Methylcyclohexane	0.023	0.009	0.104
Toluene	0.058	0.020	0.252
Other C8's	0.000	0.000	0.000
n-Octane	0.006	0.003	0.032
Ethylbenzene	0.000	0.000	0.000
M & P Xylenes	0.020	0.008	0.101
O-Xylene	0.004	0.002	0.021
Other C9's	0.000	0.000	0.000
n-Nonane	0.003	0.002	0.019
Other C10's	0.000	0.000	0.000
n-Decane	0.000	0.000	0.000
Undecanes (11)	0.000	0.000	0.000
Totals	100.000	6.560	100.000

Computed Real Characteristics Of Total Sample:

Specific Gravity	0.735	(Air=1)
Compressibility (Z)	0.9963	
Molecular Weight	21.21	
Gross Heating Value		
Dry Basis	1272	BTU/CF
Saturated Basis	1250	BTU/CF

February 10, 2016

FESCO, Ltd.
1100 Fesco Avenue - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Date Sampled: 01/19/16

Date Analyzed: 01/26/16

Job Number: J61194

Sample: Cotton Hills CTB

FLASH LIBERATION OF SEPARATOR WATER		
	Heater Treater	Stock Tank
Pressure, psig	25	0
Temperature, °F	76	70
Gas Water Ratio (1)	------	0.16
Gas Specific Gravity (2)	------	0.834

(1) - Scf of water saturated vapor per barrel of stock tank water
(2) - Air = 1.000
(3) - Separator volume / Stock tank volume
Analyst: T.G.

Piston No. : PW-0406

Base Conditions: 15.025 PSI & 60 °F

Certified: FESCO, Ltd. - Alice, Texas

David Dannhaus 361-661-7015

February 2, 2016

FESCO, Ltd.
1100 Fesco Ave. - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Sample: Cotton Hills CTB
Gas Liberated From Heater Treater Water
From 25 psig & 76 °F to 0 psig & 70 °F

Date Sampled: 01/19/16 Job Number: 61194.021

CHROMATOGRAPH EXTENDED ANALYSIS - SUMMATION REPORT - GPA 2286

COMPONENT	MOL%	GPM
Hydrogen Sulfide*	< 0.001	
Nitrogen	8.825	
Carbon Dioxide	0.455	
Methane	62.634	
Ethane	15.888	4.333
Propane	7.667	2.154
Isobutane	0.652	0.217
n-Butane	1.931	0.621
2-2 Dimethylpropane	0.007	0.003
Isopentane	0.299	0.112
n-Pentane	0.336	0.124
Hexanes	0.236	0.099
Heptanes Plus	1.068	0.399
Totals	100.000	8.063

Computed Real Characteristics Of Heptanes Plus:

Specific Gravity	3.246	(Air=1)
Molecular Weight	93.59	
Gross Heating Value	4798	BTU/CF

Computed Real Characteristics Of Total Sample:

Specific Gravity	0.834	(Air=1)
Compressibility (Z)	0.9956	
Molecular Weight	24.05	
Gross Heating Value		
Dry Basis	1312	BTU/CF
Saturated Basis	1290	BTU/CF

*Hydrogen Sulfide tested in laboratory by: Stained Tube Method (GPA 2377)
Results: <0.013 Gr/100 CF, <0.2 PPMV or <0.001 Mol %

Base Conditions: 15.025 PSI & 60 Deg F

Sampled By: (16) T. Gonzalez
Analyst: HB
Processor: OA
Cylinder ID: WF# 9S

Certified: FESCO, Ltd. - Alice, Texas

David Dannhaus 361-661-7015

CHROMATOGRAPH EXTENDED ANALYSIS
TOTAL REPORT - GPA 2286

COMPONENT	MOL %	GPM	WT %
Hydrogen Sulfide*	< 0.001		< 0.001
Nitrogen	8.825		10.281
Carbon Dioxide	0.455		0.833
Methane	62.634		41.785
Ethane	15.888	4.333	19.867
Propane	7.667	2.154	14.060
Isobutane	0.652	0.217	1.575
n-Butane	1.931	0.621	4.668
2,2 Dimethylpropane	0.007	0.003	0.022
Isopentane	0.299	0.112	0.898
n-Pentane	0.336	0.124	1.008
2,2 Dimethylbutane	0.000	0.000	0.000
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.066	0.028	0.236
2 Methylpentane	0.053	0.022	0.189
3 Methylpentane	0.036	0.015	0.127
n-Hexane	0.082	0.034	0.293
Methylcyclopentane	0.088	0.031	0.310
Benzene	0.251	0.072	0.815
Cyclohexane	0.119	0.041	0.418
2-Methylhexane	0.011	0.005	0.046
3-Methylhexane	0.015	0.007	0.061
2,2,4 Trimethylpentane	0.000	0.000	0.000
Other C7's	0.046	0.020	0.189
n-Heptane	0.031	0.015	0.129
Methylcyclohexane	0.076	0.031	0.310
Toluene	0.207	0.071	0.794
Other C8's	0.026	0.012	0.121
n-Octane	0.023	0.012	0.110
Ethylbenzene	0.007	0.003	0.031
M & P Xylenes	0.076	0.030	0.335
O-Xylene	0.020	0.008	0.087
Other C9's	0.016	0.008	0.086
n-Nonane	0.017	0.010	0.092
Other C10's	0.024	0.014	0.142
n-Decane	0.014	0.009	0.082
Undecanes (11)	0.000	0.000	0.000
Totals	100.000	8.063	100.000

Computed Real Characteristics Of Total Sample:

Specific Gravity	0.834	(Air=1)
Compressibility (Z)	0.9956	
Molecular Weight	24.05	
Gross Heating Value		
Dry Basis	1312	BTU/CF
Saturated Basis	1290	BTU/CF

February 8, 2016

FESCO, Ltd.
1100 Fesco Ave. - Alice, Texas 78332

For: Chevron North America Exploration and Production Company
15 Smith Road
Midland, Texas 79705

Sample: Cotton Hills CTB
Breathing Vapor From Residual Flash Hydrocarbon Liquid
From 0 psig & 70 °F to 0 psig & 100 °F

Date Sampled: 01/19/16 Job Number: 61194.071

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2286

COMPONENT	MOL%	GPM
Hydrogen Sulfide*	< 0.001	
Nitrogen	0.000	
Carbon Dioxide	0.011	
Methane	1.411	
Ethane	10.702	2.919
Propane	34.542	9.704
Isobutane	8.903	2.971
n-Butane	24.356	7.830
2-2 Dimethylpropane	0.094	0.037
Isopentane	6.043	2.254
n-Pentane	6.741	2.492
Hexanes	3.798	1.595
Heptanes Plus	3.399	1.406
Totals	100.000	31.208

Computed Real Characteristics Of Heptanes Plus:

Specific Gravity	3.398	(Air=1)
Molecular Weight	95.55	
Gross Heating Value	5088	BTU/CF

Computed Real Characteristics Of Total Sample:

Specific Gravity	1.914	(Air=1)
Compressibility (Z)	0.9708	
Molecular Weight	53.82	
Gross Heating Value		
Dry Basis	3183	BTU/CF
Saturated Basis	3128	BTU/CF

*Hydrogen Sulfide tested in laboratory by: Stain Tube Method (GPA 2377)
Results: <0.013 Gr/100 CF, <0.2 PPMV or <0.001 Mol %

Base Conditions: 15.025 PSI & 60 Deg F

Sampled By: (16) T. Gonzalez
Analyst: MR
Processor: OA
Cylinder ID: BV-4

Certified: FESCO, Ltd. - Alice, Texas

David Dannhaus 361-661-7015

CHROMATOGRAPH EXTENDED ANALYSIS - GPA 2286
TOTAL REPORT

COMPONENT	MOL %	GPM	WT %
Hydrogen Sulfide*	< 0.001		< 0.001
Nitrogen	0.000		0.000
Carbon Dioxide	0.011		0.009
Methane	1.411		0.420
Ethane	10.702	2.919	5.979
Propane	34.542	9.704	28.299
Isobutane	8.903	2.971	9.614
n-Butane	24.356	7.830	26.301
2,2 Dimethylpropane	0.094	0.037	0.126
Isopentane	6.043	2.254	8.100
n-Pentane	6.741	2.492	9.036
2,2 Dimethylbutane	0.066	0.028	0.106
Cyclopentane	0.000	0.000	0.000
2,3 Dimethylbutane	0.362	0.151	0.580
2 Methylpentane	1.204	0.510	1.928
3 Methylpentane	0.618	0.257	0.989
n-Hexane	1.548	0.649	2.478
Methylcyclopentane	0.597	0.210	0.934
Benzene	0.059	0.017	0.086
Cyclohexane	0.587	0.204	0.917
2-Methylhexane	0.170	0.081	0.316
3-Methylhexane	0.181	0.084	0.337
2,2,4 Trimethylpentane	0.000	0.000	0.000
Other C7's	0.484	0.215	0.892
n-Heptane	0.356	0.167	0.663
Methylcyclohexane	0.443	0.182	0.808
Toluene	0.051	0.017	0.087
Other C8's	0.314	0.149	0.643
n-Octane	0.064	0.033	0.136
Ethylbenzene	0.002	0.001	0.004
M & P Xylenes	0.011	0.004	0.022
O-Xylene	0.002	0.001	0.004
Other C9's	0.064	0.033	0.150
n-Nonane	0.007	0.004	0.017
Other C10's	0.004	0.002	0.010
n-Decane	0.001	0.001	0.003
Undecanes (11)	0.002	0.001	0.006
Totals	100.000	31.208	100.000

Computed Real Characteristics Of Total Sample:

Specific Gravity	1.914	(Air=1)
Compressibility (Z)	0.9708	
Molecular Weight	53.82	
Gross Heating Value		
Dry Basis	3183	BTU/CF
Saturated Basis	3128	BTU/CF