BLM AIR RESOURCES TECHNICAL REPORT FOR OIL AND GAS DEVELOPMENT IN NEW MEXICO, OKLAHOMA, TEXAS, AND KANSAS

2021

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1 INTRODUCTION

The purpose of this document is to present, discuss, and summarize technical information regarding air quality, air quality–related values, greenhouse gas (GHG) emissions and climate change relative to air resources with the Bureau of Land Management (BLM) New Mexico State Office Planning areas (New Mexico, Oklahoma, Texas, and Kansas). Much of the information contained in this document is directly related to air quality in the context of oil and gas development; other information is generalized air quality data that can be applied to other development scenarios and assessments. This information can then be incorporated by reference into National Environmental Policy Act (NEPA) documents, such as leasing-level documents, and site-specific documents, such as Applications for Permit to Drill (APDs), as necessary.

Since the BLM manages extensive land holdings in New Mexico, far more of its activities are centered there. The BLM has jurisdiction over mineral rights on federal lands managed by other agencies and on split estate lands in Kansas, Texas, and Oklahoma. Wherever possible, information for those states is included.

1.1 AIR RESOURCES

Air quality, GHGs, and climate are components of air resources that may be affected by BLM applications, activities, and resource management. Therefore, the BLM must consider and analyze the potential effects of BLM and BLM-authorized activities on air resources as part of the planning and decision-making process. In particular, the activities surrounding oil and gas development are likely to have impacts related to air resources.

1.2 AIR QUALITY

The Clean Air Act (CAA), as amended, is the primary authority for regulation and protection of air quality in the United States. The Federal Land Policy and Management Act also charges BLM with the responsibility to protect air and atmospheric values. Additionally, each state, tribal, or local government holds additional authority for regulating air quality within their unique jurisdiction.

1.3 CLASS I, II, AND III AREAS AND THE CLEAN AIR ACT

All areas of the United States not specifically classified as Class I by the CAA are considered to be Class II for air quality. Class I areas are afforded the highest level of protection by the CAA and include all international parks, national wilderness areas and national memorial parks greater than 5,000 acres, and national parks greater than 6,000 acres in size that were in existence on August 7, 1977. Moderate amounts of air quality degradation are allowed in Class II areas. While the CAA allows for designation of Class III areas where greater amounts of degradation would be allowed, no areas have been designated as such by the U.S. Environmental Protection Agency (EPA). Air quality in a given area is determined by comparing monitored air pollution levels using air monitoring equipment operated in accordance with federal regulatory standards with National Ambient Air Quality Standards (NAAQS) set by the CAA. In some cases, states have set their own ambient air quality standards in accordance with provisions of the CAA.

Regulation and enforcement of the NAAQS has been delegated to the states by the EPA. Both the NAAQS and the New Mexico Ambient Air Quality Standards (NMAAQS) are shown in Table 1. Texas has state property line standards for sulfur dioxide (SO_2) and certain non-criteria pollutants. Other than the addition of a 30-minute SO_2 state property line standard which varies based on which county a project is located, there are no other differences between state standards and the NAAQS in Texas. Oklahoma and Kansas do not have state standards for criteria pollutants that differ from the NAAQS (see Table 1).

The regulatory authority for air quality in New Mexico is the New Mexico Environment Department (NMED) Air Quality Bureau (NMED 2022a). The regulatory authority for air quality in Kansas is the Kansas Department of Health and Environment, Bureau of Air (2022). The regulatory authority for air quality in Oklahoma is the Oklahoma Department of Environmental Quality, Air Quality Division (ODEQ AQD) (2022). The regulatory authority for air quality in Texas is the Texas Commission on Environmental Quality (TCEQ), Air Division (TCEQ 2022a).

2 CRITERIA AIR POLLUTANTS

The EPA has the primary responsibility for regulating atmospheric emissions, including six nationally regulated air pollutants defined in the CAA. These pollutants, referred to as “criteria pollutants,” are carbon monoxide (CO), nitrogen dioxide (NO_2 or NO_X), ozone (O_3), particulate matter (PM_{10} and $PM_{2.5}$), SO_2 (SO_2 or SO_X), and lead (Pb). The CAA charges the EPA with establishing and periodically reviewing NAAQS for each criteria pollutant. Table 1 shows the current primary and secondary NAAQS standards and averaging time for each pollutant, as well as the New Mexico–specific NMAAQS levels for select pollutants. Primary standards are set to protect the public health with a margin of safety, and secondary standards are meant to protect environmental concerns such as air quality related values (AQRVs) (visibility, vegetation injury, etc.).

Table 1. NAAQS and NMAAQS

Pollutant	Primary Standards		Secondary Standards		NMAAQS Level (Averaging Time)
	Level	Averaging Time	Level	Averaging Time	
CO	9 parts per million (ppm) (10 milligrams/ cubic meter [mg/m^3])	8-hour(1)	None	None	8.7 ppm
	35 ppm (40 mg/m^3)	1-hour(1)	None	None	13.1 ppm
Pb	0.15 micrograms/ cubic meter (µg/m^3)	Rolling 3-month average(2)	Same as primary	Same as primary	None
NO_2 (or NO_x)	53 parts per billion (ppb) (100 µg/m^3)	Annual (arithmetic average)	Same as primary		50 ppb
	100 ppb (188 µg/m^3)	1-hour(3)	None		100 ppb (24-hour)
PM_{10}	150 µg/m^3	24-hour(4)	Same as primary		*

Pollutant	Primary Standards		Secondary Standards		NMAAQS Level (Averaging Time)
	Level	Averaging Time	Level	Averaging Time	
$PM_{2.5}$	12.0 μg/m^3	Annual(5) (arithmetic average)	15.0 ug/m^3	(annual)(5) (arithmetic average)	*
	35 μg/m^3	24-hour(6)	Same as primary		*
O_3	0.070 ppm (137 μg/m^3)	8-hour(7)	Same as primary		None
SO_2 (or SO_x)	75 ppb (196 μg/m^3)	1-hour(8)	0.5 ppm(1) (1,300 μg/m^3)	3-hour	0.02 ppm (annual)** 0.10 ppm (24-hour)**

Source: EPA (2022a)

*The New Mexico Environmental Improvement Board repealed the Total Suspended Particle NMAAQS in New Mexico Administrative Code (NMAC) 20.2.3, Ambient Air Quality Standards effective November 30, 2018, and therefore, total suspended particles will no longer be reported. A determination was made that the current state and federal air quality standards for PM_{10} and $PM_{2.5}$ are sufficiently protective of public health and that that the repeal of the total suspended particles standard will not result in deterioration of air quality.

** For additional standards of air quality related to sulfur compounds in specific areas such as Chino Mines Company smelter furnace stack at Hurley and the Pecos-Permian basin intrastate air quality control region, see NMAC 20.2.3 and Table 6 of this report.

(1) Not to be exceeded more than once per year.

(2) Not to be exceeded.

(3) To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).

(4) Not to be exceeded more than once per year on average over 3 years.

(5) To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not be exceeded.

(6) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 μg/m^3 (effective December 17, 2006).

(7) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average O_3 concentrations measured at each monitor within an area over each year must not exceed 0.070 ppm.

(8) To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

EPA's New Source Performance Standards (NSPS) rules are designed to regulate criteria air pollutant and O_3 precursor emissions. The EPA NSPS regulations that are most likely to have applicability to oil and gas operations are as follows:

- NSPS Subpart JJJJ – Standards of Performance for Stationary Spark Ignition Internal Combustion Engines
- NSPS Kb – Standards of Performance for Volatile Organic Liquid Storage Vessels (Including Petroleum Liquid Storage Vessels) for which Construction, Reconstruction, or Modification Commenced After July 23, 1984.

- NSPS OOOO – Standards of Performance for Crude Oil and Natural Gas Production, Transmission and Distribution
- NSPS OOOOa – Crude Oil and Natural Gas Facilities for which Construction, Modification, or Reconstruction Commenced After September 18, 2015: NSPS – Originally this rule and its draft was promulgated to regulate volatile organic compounds (VOCs) and GHG emissions (methane [CH_4]) from specific sources within the oil and natural gas industry which would have included new, modified, and reconstructed compressors, pneumatic controllers, pneumatic pumps, storage vessels, well completions, fugitive emissions from well sites and compressor stations, and equipment leaks at natural gas processing plants. In September 2018 and August 2019, the EPA proposed changes to the rule to modify, amend and/or rescind requirements for the 2012 and 2016 NSPS for the Oil and Gas Industry, which have been incorporated into the final rule as of September 14, 2020.

2.1 OZONE AND VOLATILE ORGANIC COMPOUNDS

Ground-level O_3 is not emitted directly into the air but is created by chemical reactions between precursors—oxides of nitrogen (NO_x)[1] and VOCs—in the presence of sunlight (Figure 1). While O_3 and NO_2 are criteria air pollutants, VOCs are not. Figure 1 uses a graphical representation to show how O_3 is created in the atmosphere.

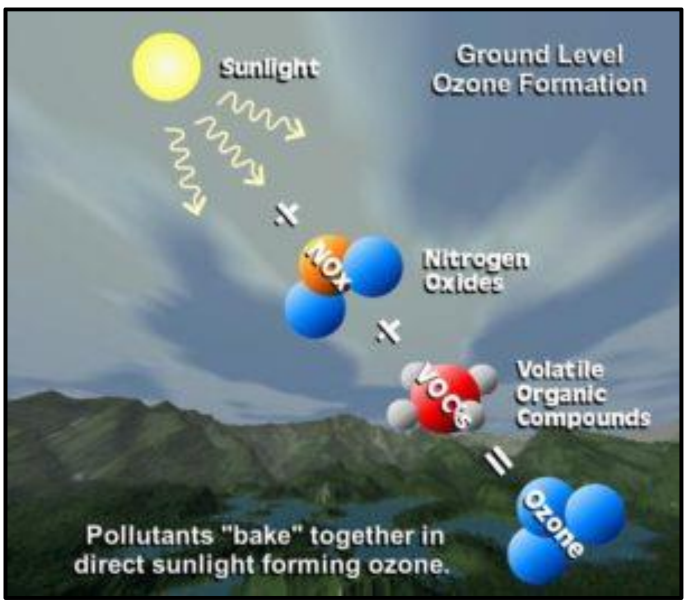


Figure 1. O_3 formation, courtesy of NASA

VOCs are components of natural gas and may be emitted from well drilling, operations, and equipment leaks, valves, pipes, and pneumatic devices. Additionally, VOCs are emitted from a variety of sources, such as refineries, oil and gas production equipment, consumer products, and natural (biogenic) sources, such as trees and plants. More information on VOCs during the well completion process is discussed further in the report.

[1] The nitrogen oxide family of compounds includes nitric oxide (NO), NO_2, nitrous acid (HNO_2), and nitric acid (HNO_3).

O_3 is most likely to reach unhealthy levels on hot, sunny days but can still reach high levels during colder months. O_3 can also be transported long distances by wind (EPA 2022b).

People most at risk from breathing air containing O_3 include people with asthma, children, older adults, and people who are active outdoors, especially outdoor workers. In addition, people with certain genetic characteristics, and people with reduced intake of certain nutrients, such as vitamins C and E, are at greater risk from O_3 exposure (EPA 2022b). Deficiencies of vitamin E, a fat-soluble nutrient, is uncommon in developed countries but do occur in those individuals with conditions that prevent the body from adequately absorbing fats (e.g., chronic pancreatitis, cholestasis, cystic fibrosis, primary biliary, cirrhosis, Crohn's disease, or short bowel syndrome). Vitamin C deficiency and scurvy are rare in developed countries, as overt deficiency symptoms occur only if vitamin C intake falls below approximately 10 mg/day for many weeks; however, vitamin C deficiency can still occur in people with limited food variety or those with intestinal problems such as ulcerative colitis or Crohn's disease. Children are at greatest risk from exposure to O_3 because their lungs are still developing and they are more likely to be active outdoors when O_3 levels are high, which increases their exposure. Children are also more likely than adults to have asthma (EPA 2022b).

Depending on the level of exposure, breathing O_3 can trigger a variety of health problems. Effects of O_3 inhalation can include coughing and sore or scratchy throat; difficulty breathing deeply and vigorously and pain when taking deep breaths; inflammation and damage the airways; increased susceptibility to lung infections; aggravation of lung diseases such as asthma, emphysema, and chronic bronchitis; and an increase in the frequency of asthma attacks. Some of these effects have been found even in healthy people, but effects are more serious in people with lung diseases such as asthma. O_3 exposure may lead to increased school absences, medication use, visits to doctors and emergency rooms, and hospital admissions. Long-term exposure to O_3 is linked to aggravation of asthma and is likely to be one of many causes of asthma development. Studies in locations with elevated concentrations also report associations of O_3 with deaths from respiratory causes (EPA 2022b). Asthma often starts during childhood when the immune system is still developing. Multiple factors may work together to cause asthma, such as allergens in the environment that affect babies or young children, including cigarette smoke and certain germs; viral infections that affect breathing; and family history, such as a parent (in particular, a mother) who has asthma. Common triggers for asthma include indoor allergens, such as dust mites, mold, and pet dander or fur; outdoor allergens, such as pollens and mold; emotional stress; physical activity (although with treatment, most individuals can still be active); infections, such as colds, influenza (flu), or COVID-19; certain medicines, such as aspirin, which may cause serious breathing problems in people with severe asthma; poor air quality (such as high levels of O_3); or very cold air (National Heart, Lung, and Blood Institute 2022).

The environmental effects of O_3 include damaging sensitive vegetation and ecosystems. In particular, O_3 harms sensitive vegetation during the growing season (EPA 2022b). Plant species that are sensitive to the O_3 in terms of growth effects include trees found in many areas of the United States, such as black cherry (*Prunus serotina*), quaking aspen (*Populus tremuloides*), tulip poplar (*Liriodendron tulipifera*), white pine (*Pinus strobus*), ponderosa pine (*Pinus ponderosa*) and red alder (*Ainus rubra*). When sufficient O_3 enters the leaves of a sensitive plant, it can reduce photosynthesis, which is the process by which plants convert sunlight to energy to live and grow. O_3 can also slow a plant's growth and increase its risk of disease, damage from insects, effects of other pollutants, and damage from severe weather. The effects of O_3 on individual plants can then have negative impacts on ecosystems, including loss of species diversity, changes to the specific assortment of plants present in a forest, changes to habitat quality, and changes to water and nutrient cycles (EPA 2022b).

2.1.1 OZONE TRENDS

Nationally, O_3 concentrations at urban and rural sites have decreased 29% from 1980 to 2021. The increase of O_3-depleting substance (ODS) concentrations caused the large O_3 decline observed from 1980 to the mid-1990s. Since the late 1990s, concentrations of O_3-depleting substances have been declining due to the successful implementation of the Montreal Protocol on Substances that Deplete the Ozone Layer. The long-term decrease is also likely driven by reductions in global emissions of substances that lead to the formation of O_3, such as O_3 precursors VOCs and NO_x. In correlation over the same period, emissions of VOCs and NO_x have decreased by 61% and 72%, respectively. Nevertheless, some areas still experience exceedances as discussed in Section 2.6. Weather conditions have a significant role in the formation of O_3, which is most readily formed on warm summer days when there is stagnation. Conversely, ozone production is more limited when it is cloudy, cool, rainy, or windy. EPA uses a statistical model to adjust for the variability in seasonal ozone concentrations due to weather to provide a more accurate assessment of the underlying trend in ozone caused by emissions, however often long time periods are required to distinguish between weather effects and the effect of changes in pollutant emissions. Table 2 shows the O_3 trends in specific cities within the BLM New Mexico State Office's (NMSO's) area of operations.

Table 2. Local O_3 Trends

City, State	2000 Design Value (ppm)	2010 Design Value (ppm)	2021 Design Value (ppm)	2000–2021 Trend*
Carlsbad-Artesia, NM	0.069	0.069	0.080	16%
Farmington, NM	0.08	0.064	0.068	-15%
Tulsa, OK	0.08	0.07	0.065	-19%
Oklahoma City, OK	0.081	0.071	0.069	-15%
Wichita, KS	0.081	0.075	0.062	-23%
Houston-The Woodlands-Sugar Land, TX	0.10	0.079	0.072	-28%
Longview, TX	0.099	0.078	0.064	-35%
Dallas-Fort Worth-Arlington, TX	0.09	0.076	0.072	-20%
Austin-Round Rock, TX	0.088	0.072	0.066	-25%
El Paso, TX	0.078	0.068	0.067	-14%

Source: EPA (2022c)

* A positive percentage means that O_3 concentrations have increased from 2000 to 2021, while a negative percentage means that O_3 concentrations have decreased from 2000 to 2021.

2.1.1.1 Nitrogen Dioxide

Nitrogen dioxide (NO_2) is both a criteria pollutant and an indicator for the NO_x family of nitrogen oxide compounds that are ground-level O_3 precursors. The nitrogen oxide family of compounds includes nitric oxide (NO), NO_2, nitrous acid (HNO_2), and nitric acid (HNO_3). The primary sources of NO_x nationally are from the burning of fuel. The excess air required for complete combustion of fuels introduces atmospheric nitrogen into the combustion reactions at high temperatures and produces nitrogen oxides. Breathing air with a high concentration of NO_2 can cause adverse respiratory impacts in both healthy people and those with asthma (EPA 2022a).

Nationally, NO_2 concentrations have decreased substantially (64% reduction) from 1980 to 2021 due to improvements in motor vehicle emissions controls. In the southwest (Arizona, New Mexico, Colorado, and Utah), NO_2 concentrations have decreased 38% between 2000 and 2021; in the south (Texas, Oklahoma, Kansas, Arkansas, Louisiana, and Mississippi), NO_2 concentrations have decreased 35% between 2000 and 2021. EPA expects NO_2 concentrations will continue to decrease (EPA 2022d).

2.2 CARBON MONOXIDE

CO is produced from the incomplete burning of carbon-containing compounds such as fossil fuels; it forms when there is not enough oxygen to produce carbon dioxide (CO_2).

Breathing air with a high concentration of CO reduces the amount of oxygen that can be transported in the blood stream to critical organs like the heart and brain. At very high levels, which are possible indoors or in other enclosed environments, CO can cause dizziness, confusion, unconsciousness, and death. Very high levels of CO are not likely to occur outdoors. However, when CO levels are elevated outdoors, they can be of particular concern for people with some types of heart disease (EPA 2022b).

Nationally, CO concentrations have decreased 87% from 1980 to 2021 due to improvements in motor vehicle emissions controls. Monitored CO concentrations in the southwest region (New Mexico, Arizona, Colorado, and Utah) have decreased 70% between 2000 and 2021. Monitored CO concentrations in the south region (Texas, Oklahoma, Kansas, Arkansas, Louisiana, and Mississippi) have decreased 71% between 2000 and 2021 (EPA 2022e).

2.3 PARTICULATE MATTER

Particulate matter, also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. PM is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. PM is measured and regulated according to particle size. PM_{10} refers to all particles with a diameter of 10 microns or less. $PM_{2.5}$ is made up of particles with diameters of 2.5 microns or less. Smaller particles are associated with more negative health effects, including respiratory and cardiovascular problems, because they can become more deeply embedded in the lungs and some may even get into the bloodstream (EPA 2022f).

Nationally, $PM_{2.5}$ concentrations have decreased 37% from 2000 to 2021. In that same time period, PM_{10} concentrations decreased 32% nationally. In the southwest (New Mexico, Arizona, Colorado, and Utah), $PM_{2.5}$ concentrations have decreased 13% from 2000 to 2021, and PM_{10} concentrations have decreased 22% during the same time period. For the southern region encompassing Texas, Oklahoma, Kansas, Arkansas, Louisiana, and Mississippi, $PM_{2.5}$ concentrations have decreased 29% and PM_{10} concentrations have increased 20% between 2000 and 2021 (EPA 2022g, 2022h).

2.4 SULFUR DIOXIDE

SO_2 is one of a group of highly reactive gases known as "oxides of sulfur," commonly referred to as SO_x. The largest sources of SO_2 emissions nationwide are from fossil fuel combustion at power plants (73%) and other industrial facilities (20%). Smaller sources of SO_2 emissions include industrial processes, such as extracting metal from ore, and the burning of high sulfur-containing fuels by locomotives, large ships, and non-road equipment. SO_2 is linked with a number of adverse effects on the respiratory system. At high concentrations, gaseous SO_x can harm trees and plants by damaging foliage and decreasing growth. SO_2 and other sulfur oxides can contribute to acid rain, which can harm sensitive ecosystems (EPA 2022t).

Nationally, SO_2 concentrations have decreased 85% from 2000 to 2021, but substantial decreases (94% reduction) have occurred since 1980 due to implementation of federal rules requiring reductions in SO_2 emissions from power plants and other large sources of SO_2. In the southwest, SO_2 concentrations decreased 94% between 2000 and 2021. In the southern region of the United States (Texas, Oklahoma, Kansas, Arkansas, Louisiana, and Mississippi), SO_2 concentrations decreased 80% between 2000 and 2021 (EPA 2022i).

2.5 LEAD

With the elimination of lead from gasoline and regulation of industrial sources, levels of lead in the atmosphere decreased 98% nationwide between 1980 and 2014. Lead concentrations decreased 85% nationally between 2010 and 2021. Lead is still regulated as a criteria pollutant, and its main sources are lead smelters and leaded aviation gasoline. In 2014, EPA proposed to retain the NAAQS for lead without revision (EPA 2020a).

2.6 MONITORING DATA AND DESIGN VALUES

Criteria pollutants are monitored throughout various parts of the country. Monitors measure concentrations of pollutant in the atmosphere and the results are often presented in parts per million (ppm) or micrograms per cubic meter ($\mu g/m^3$). EPA and states periodically analyze and review monitor locations, discontinuing monitoring at locations where pollutant concentrations have been well below the standards and adding monitors in areas where pollutant concentrations may be approaching air quality standards. *Instantaneous on-demand* monitored outdoor air quality data collected from state, local, and tribal monitoring agencies can be obtained from EPA's Air Data webpage and interactive tool (EPA 2022k).

Another type of monitoring data is *annual average concentration(s)* measured at air monitors, which are then translated to annual design values to be consistent with the individual NAAQS in Table 1. A design value is a statistic representing the monitored concentration of a given pollutant in a given location, expressed in the manner of its standard, which can be compared with the NAAQS. Design values are normally updated annually and posted to the EPA's Air Quality Design Value website. The most recent, 2021 design values for the measured criteria pollutants of the counties in the major oil and gas basins of New Mexico are provided in Table 3 and Table 4. The 2021 design values are compared with the NAAQS and NMAAQS for those New Mexico counties with available data. Rural counties, such as McKinley County, may not have existing monitors and, therefore, no data are available; other counties, such as San Juan County, may have monitors that record only certain pollutants. Design values are typically used to designate and classify nonattainment areas, as well as to assess progress toward meeting the NAAQS. Therefore, when the design values exceed the NAAQS or NMAAQS, actions may be taken to reassess these areas' designations.

Table 3. 2021 Design Values for Eddy and Lea Counties

Pollutant	2021 Design Values	Averaging Time	NAAQS	NMAAQS[(5)]
O_3	0.077 ppm (Eddy County), 0.066 ppm (Lea County)	8-hour[(1)]	0.070 ppm	–
NO_2	5 ppb (Eddy County), 4 ppb (Lea County)	Annual[(2)]	53 ppb	50 ppb
NO_2	29 ppb (Eddy County), 32 ppb (Lea County)	1-hour[(3)]	100 ppb	–
$PM_{2.5}$[4]	6.5 micrograms per cubic meter (μg/m^3) (Lea County)	Annual[(4)]	12 μg/m^3	–
$PM_{2.5}$	17 μg/m^3 (Lea County)	24-hour[(3)]	35 μg/m^3	–

Source: EPA (2022l)

(1) Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.

(2) Not to be exceeded during the year.

(3) 98th percentile, averaged over 3 years.

(4) Annual mean, averaged over 3 years.

(5) The NMAAQS standard for total suspended particulates, which was used as a comparison for PM_{10} and $PM_{2.5}$, was repealed as of November 30, 2018. Where no standards are presented, the NAAQS still apply.

Note: While there are no NAAQS for hydrogen sulfide (H_2S), New Mexico has set 0.5-hour standards for H_2S at 0.100 ppm within the Pecos-Permian Air Quality Control Region and 0.030 ppm for municipal boundaries and within 5 miles of municipalities with populations greater than 20,000 in areas of the state outside of the area within 5 miles of the Pecos-Permian Air Quality Control Region (see Table 6).

Table 4. 2021 Design Values for Rio Arriba, Sandoval, and San Juan Counties

Pollutant	2021 Design Concentrations	Averaging Time	NAAQS	NMAAQS[(7)]
O_3	Rio Arriba County: 0.064 ppm Sandoval County: 0.068 ppm San Juan County: 0.068 ppm, four stations; Bloomfield at 0.063 ppm, Navajo Dam at 0.068 ppm, Shiprock at 0.068 ppm, Chaco Culture National Historical Park at 0.068 ppm	8-hour[(1)]	0.070 ppm	–
NO_2	San Juan County: 9 ppb, four stations; Bloomfield at 9 ppb, Navajo Dam at 6 ppb, Chaco Culture at 1 ppb and Shiprock at 3 ppb	Annual[(2)]	53 ppb	50 ppb
NO_2	San Juan County: 32 ppb, four stations; Bloomfield at 32 ppb, Navajo Dam at 23 ppb, Chaco Culture invalid, Shiprock at 23 ppb	1-hour[(3)]	100 ppb	–
SO_2	San Juan County: 1 ppb	1-hour[(5)]	75 ppb	–
$PM_{2.5}$	No monitor data nearby[8]	Annual[(4,6)]	60 μg/m^3	–
$PM_{2.5}$	No monitor data nearby[8]	24-hour[(3,6)]	35 μg/m^3	–

Source: EPA (2022l)

(1) Annual fourth highest daily maximum 8-hour concentration, averaged over 3 years.

(2) Not to be exceeded during the year.

(3) 98th percentile, averaged over 3 years.

(4) Annual mean, averaged over 3 years.

(5) 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years.

(6) $PM_{2.5}$ monitor stations currently show installed locations in the planning area (San Juan County); however, the monitor status of these stations show invalid data and cannot be used to represent design values.

(7) The NMAAQS standard for total suspended particulates, which was used as a comparison with PM_{10} and $PM_{2.5}$, was repealed as of November 30, 2018. Where no standards are presented, the NAAQS still apply.

(8) Many rural counties have no monitoring data and are assumed under the CAA to be in attainment.

Note: While there are no NAAQS for H_2S, New Mexico has set a 1-hour standard for H_2S at 0.010 ppm for all areas of the state outside of the area within 5 miles of the Pecos-Permian Air Quality Control Region.

2.7 GENERAL CONFORMITY AND NONATTAINMENT

If the concentration of one or more criteria pollutants in a geographic area is found to violate the NAAQS, the area may be classified as a **nonattainment** area. Areas with concentrations of criteria pollutants that are below the levels established by the NAAQS are considered either **attainment** or unclassifiable areas. Areas for which available data are not sufficient to make an attainment status designation are listed as unclassifiable. When a state submits a request to the EPA to redesignate a nonattainment area as an attainment area, it must submit a maintenance plan that demonstrates that the area can maintain the air-quality standard for at least 10 years following the effective date of redesignation. An EPA approved maintenance plan will allow the EPA to re-designate the area as an attainment area and in the interim is classified as maintenance areas.

To eliminate or reduce the severity and number of NAAQS violations in nonattainment areas, and to achieve expeditious attainment of the NAAQS, the EPA promulgated the Conformity Rule (40 Code of Federal Regulations [C.F.R.] 6, 51, 93). The Conformity Rule applies to federal actions and environmental analyses in nonattainment and maintenance areas completed after March 15, 1994. This rule contains a variety of substantive and procedural requirements to show conformance with both the NAAQS and state implementation plans (SIPs).

Section 176(c) of the CAA prohibits federal agencies from taking actions in nonattainment and maintenance areas unless the emissions from the actions conform to the SIP or tribal implementation plan for the area. Federal actions must be evaluated for conformity to the local SIP if the project 1) is located within an EPA-designated nonattainment or maintenance area, 2) would result in emissions above the de minimis threshold quantities of criteria pollutants listed in 40 C.F.R. 93, 3) is not a listed exempt action, and 4) has not been accounted for in an EPA-approved SIP.

EPA's conformity rule requires that all federal actions in a nonattainment area must demonstrate conformity with the SIP for the pollutant in question. If the agency can demonstrate that emissions for the action will fall below certain established levels, known as de minimis, then no further analysis is necessary. To establish a de minimis claim, an emissions inventory for the project is required. In the case of O_3, the emissions inventory would include NO_x and VOCs. If emissions are projected to be above de minimis levels, a formal Conformity Determination may be required.

Nonattainment designation is classified on six levels depending on the design value and pollutant, with the lowest level starting at marginal and increasing in severity: marginal, moderate, serious, severe-15, severe-17, and extreme. Nonattainment areas in New Mexico are as follows:

- **O_3 nonattainment area in Doña Ana County (Sunland Park, New Mexico, located southwest of the Carlsbad Field Office [CFO] planning area, south of Las Cruces):** In 1995, the EPA declared a 42 square-mile region in the southeast corner of the county on the border of Texas and Mexico as a marginal nonattainment area for the 1-hour O_3 standard. The nonattainment area included the City of Sunland Park, Santa Teresa, and La Union, New Mexico. The 1-hour O_3 standard was revoked by EPA in 2004 with the adoption of the new 8-hour O_3 standard. Due to the revocation of the 1979 1-hour O_3 standard and based on monitoring data, Sunland Park was designated as attainment for the 1997 8-hour O_3 standard (0.080 ppm).

In October 2015, the EPA lowered the NAAQS for O_3 to 0.070 ppm. As a result, in 2016, NMED recommended that the EPA designate a portion of Doña Ana County near Sunland Park, New Mexico, as nonattainment. Based on 2014–2016 O_3 monitoring data, EPA designated the Sunland Park area in southern Doña Ana County as a marginal nonattainment area for 2015 O_3 NAAQS on June 18, 2018, with an attainment deadline of August 3, 2021 (Federal Register 83:25776) (NMED 2020). On November 30, 2021 (Federal Register 86:67864), the EPA expanded the marginal nonattainment area that previously covered only the Sunland Park area in Doña Ana County to include El Paso County, Texas, and renamed the marginal nonattainment designated area as the El Paso-Las Cruces, TX-NM nonattainment area.

On December 6, 2018 (Federal Register 83:6299), the EPA published the Nonattainment Area SIP Requirements rule that establishes the minimum elements that must be included in all nonattainment SIPs, including the requirements for New Mexico Nonattainment New Source Review (NNSR) permitting. On August 10, 2021, the NMED submitted a SIP to the New Mexico NNSR permitting program to address the requirements of the 2015 8-hour O_3 NAAQS. As of August 29, 2022, the EPA is proposing to approve the August 10, 2021, New Mexico SIP that updated the NNSR permitting program for the 2015 8-hour O_3 NAAQS (Federal Register 87:51041 and 86:57388).

- **O_3 Design Value Exceedance in Eddy County (Carlsbad, New Mexico):** In May 2021, new design values for NAAQS were published by the EPA for various counties throughout the United States. The monitor at 2811 Holland Street in Eddy County showed an 8-hour O_3 exceedance, 77 ppb (EPA 2022l). This area has not been formally declared nonattainment by the EPA through the State's recommendation but may be designated as nonattainment in the future.

  New Mexico statutes, N.M.S.A. 1978, § 74-2-5, directs NMED to develop plans that may include regulations more stringent than federal rules for areas of the state in which ambient monitoring shows O_3 levels at or above 95% of the NAAQS to control NO_x and VOC emissions to provide for attainment and maintenance of the standard. The 2015 8-hour primary NAAQS for O_3 is 0.070 ppm (or 70 ppb); 95% of the O_3 NAAQS is 0.067 ppm (67 ppb). This form of the standard requires averaging of 3 years of monitoring data for the fourth highest 8-hour average, using the most recent year's data to determine the "design value." For New Mexico, five counties show 3-year averages (2019–2021) of O_3 levels at or above 95% of the NAAQS (EPA 2022l):

  - Doña Ana County (80 ppb)
  - Eddy County (77 ppb)
  - Sandoval County (68 ppb)
  - San Juan County (68 ppb)
  - Valencia County (66 ppb)

  The NMED participates in the Ozone Advance Program for the entirety of San Juan (northwest New Mexico), Lea (southeast New Mexico), and Eddy (southeast New Mexico) Counties and for the portion of Doña Ana County that excludes the Sunland Park nonattainment area (south-central New Mexico). Since the acceptance into the Ozone Advance Program in April 2019, O_3 levels in Rio Arriba, Sandoval, Santa Fe, and Valencia Counties either currently or recently have exceeded 95% of the 2015 8-hour O_3 NAAQS (67 ppb) and could soon violate this standard. In total, the Ozone Advance Path Forward and outreach efforts includes the following nine counties: Chaves, Doña Ana, Eddy, Lea, Rio Arriba, San Juan, Santa Fe, Sandoval, and Valencia. Although Chaves County does not have O_3 monitors, the NMED includes it in the Ozone Advance Program planning effort as it is part of the Permian Basin with oil and gas emissions that contribute to high O_3 levels in Lea and Eddy Counties. The efforts under the Ozone Advance Program may benefit these areas by potentially 1) reducing air pollution in terms of O_3, as well as other air pollutants, 2) ensuring continued healthy O_3 levels, 3) maintaining the O_3 NAAQS and helping the Sunland Park nonattainment area attain the 2015 Ozone NAAQS, 4) avoiding violations of the NAAQS that could lead to a future nonattainment designation, 5) increasing public awareness about O_3 as an indirect air pollutant, and 6) targeting limited resources toward actions to address O_3 problems quickly. NMED's goal is to implement measures and programs to reduce O_3 in the near term and, ultimately, to effect changes that will protect community well-being into the future. NMED will work together and in coordination with stakeholders and the public to proactively pursue this goal (NMED 2022b).

- **PM_{10} nonattainment area in Anthony, New Mexico (located west of the CFO planning area, south of Las Cruces):** The State of New Mexico submitted the Anthony PM_{10} SIP to the regional EPA headquarters on November 8, 1991. This area was designated nonattainment for PM_{10} by the EPA in 1991. The nonattainment area is bounded by Anthony Quadrangle, Anthony, New Mexico-Texas, SE/4 La Mesa 15-minute Quadrangle, N32 00 - W106 30/7.5, Sections 35 and 36, Township 26 South, Range 3 East as limited by the New Mexico–Texas state line on the south. The site is located in Doña Ana County, which submitted a Natural Events Action Plan for PM_{10} exceedances to the EPA in December 2000. However, Anthony, New Mexico, is currently still exceeding the NAAQS for PM_{10}. Therefore, the EPA has not redesignated the State's PM_{10} nonattainment area at this time. The EPA has not indicated its plans to do so (NMED 2019a).
- The NMED Air Quality Bureau developed a Fugitive Dust Control Rule in conjunction with the mitigation plan to abate certain controllable sources in Doña Ana and Luna Counties. Mitigation plans are required by the EPA in areas where recurring natural events (in this case, high winds resulting in blowing dust) cause exceedances of the health based national standards for PM. In 2020, NMED developed a single mitigation plan for Doña Ana and Luna Counties and recently updated this plan on March 10, 2021 (NMED 2021a). The Dust Mitigation Plan and the associated Fugitive Dust Control Rule (New Mexico Administrative Code [NMAC] 20.2.23) enhance existing local dust control ordinances and provide coverage where there are gaps. The NMED Air Quality Bureau's Fugitive Dust Control Rule was published in conjunction with the original Dust Mitigation Plan and became effective on January 1, 2019. The rule applies to sources of fugitive dust that are not required to obtain a construction permit from the Air Quality Bureau, including disturbed areas greater than 1.0 acre from construction/demolition activities, and earthmoving. Control measures are required to stabilize surfaces to ensure emissions are not crossing the property line or exceeding opacity limits. Control measures listed in the rule include:
    - watering and/or applying dust suppressant unpaved surfaces,
    - limiting on-site vehicles speeds,
    - prohibiting activities during high winds,
    - watering exposed area before high winds,
    - planting trees or shrubs as a windbreak, and

- revegetating disturbed area with native plants (NMED 2021a)

- **SO_2 Maintenance Area in Grant County (located west of the CFO planning area, at the Arizona border):** This maintenance area is located at the Phelps Dodge Chino Copper Smelter in Grant County. The maintenance area is defined as a 3.5-mile-radius region around the smelter. The maintenance area also includes high-elevation areas within an 8-mile radius. The state submitted a SIP to the regional EPA headquarters in August 1978. The New Mexico Air Quality Bureau submitted a redesignation plan to the EPA in February 2003 seeking to redesignate the portion of Grant County, New Mexico, from nonattainment to attainment for the SO_2 NAAQS. In this plan, it was reported that air monitoring data for this area revealed values better than national standards for SO_2. The February 2003 submittal also included a contingency measures plan that consists of monitoring measures and a maintenance plan for this area to ensure that attainment of the SO_2 NAAQS will be maintained through permitting and the applicable SIP rules. The redesignation plan was approved by the EPA in September 2003. The Grant County SO_2 Limited Maintenance Plan was submitted to the EPA in November 2013 to fulfill the second 10-year maintenance plan requirement, under Section 175A(b) of the CAA, to ensure maintenance of the 1971 SO_2 NAAQS through 2025 and was approved by the EPA on July 18, 2014 (NMED 2019a).

Texas Nonattainment Areas: There are currently 10 key nonattainment areas in Texas: one for PM_{10} (city of El Paso); three for O_3 (Houston-Galveston-Brazoria area [eight counties], Dallas-Fort Worth area [10 counties], and Bexar County in San Antonio); and several areas not meeting the SO_2 2010 standard and therefore designated in part as nonattainment (Freestone and Anderson Counties, Howard County, Hutchinson County, Navarro County, Rusk and Panola Counties, and Titus County) (EPA 2022m).

The Houston-Galveston-Brazoria area has several counties in nonattainment status. The following counties are currently not meeting the 8-hour 2015 O_3 standard of 0.070 ppm (70 ppb): Brazoria, Chambers, Fort Bend, Galveston, Harris, and Montgomery. Each of these counties has been designated as marginal nonattainment for the 2015 O_3 nonattainment. Additionally, the six counties listed for nonattainment with the 2015 O_3 standard are also in nonattainment with the 8-hour 2008 O_3 standard along with Liberty County and Waller County. Each of these counties has been designated as serious nonattainment for the 2008 O_3 nonattainment (serious nonattainment for 2008 O_3 is an area with a design value of 0.100 up to but not including 0.113 ppm). De minimis values for areas designated as serious for both NO_x and VOCs are 50 tons per year (tpy) (EPA 2022m). The Dallas-Fort Worth area also has several counties in nonattainment status. The following counties are currently not meeting the 8-hour 2015 O_3 standard of 0.070 ppm (70 ppb): Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Tarrant, and Wise. The severity of the 2015 O_3 nonattainment for these counties is classified as marginal (an area with a design value of 0.071 up to but not including 0.081 ppm). Additionally, the following counties are designated nonattainment with respect to the 2008 8-hour O_3 standard: Collin, Dallas, Denton, Ellis, Johnson, Parker, Rockwall, Tarrant, and Wise. These counties are designated as serious nonattainment areas. De minimis values for a serious designation in this area are 50 tpy for NO_x and VOCs (EPA 2022m).

Kansas and Oklahoma

There are currently no nonattainment areas for any criteria pollutant in the states of Kansas and Oklahoma.

3 NATIONAL EMISSIONS INVENTORY DATA

The National Emissions Inventory (NEI) data present the emissions of each criteria pollutant by national, state, county, and tribal areas for major source sectors. National emissions trends are reported in the 2017 NEI report (EPA 2021). The NEI data are updated every 3 years, with new emission inventory data incurring a 2- to 3-year data gathering period for final use. The most recent NEI is for 2017, and the complete 2020 NEI data are expected to be publicly released in the spring of 2023. Emissions data are expressed in tons per year (tpy) or total volume of pollutant released to the atmosphere. Emissions data are useful in comparing source categories to determine which industries or practices are contributing the most to the general level of pollution in an area.

Details of the anthropogenic sectors mentioned in the report are:

(1) Electricity generation is fuel combustion from electric utilities.

(2) Fossil fuel combustion is fuel combustion from industrial boilers, internal combustion engines, and commercial/institutional or residential use.

(3) Industrial processes include manufacturing of chemicals, metals, and electronics; storage and transfer operations; pulp and paper production; cement manufacturing; petroleum refineries; and oil and gas production.

(4) On-road vehicles category includes both gasoline- and diesel-powered vehicles for on-road use.

(5) Non-road equipment includes gasoline- and diesel-powered equipment for non-road use, as well as planes, trains, and ships.

(6) Road dust includes dust from both paved and unpaved roads. Presentation of emissions data by source sector provides a better understanding of the activities that contribute to criteria pollutant emissions.

NEI data by pollutant (CO, NO_x, PM_{10} and $PM_{2.5}$, SO_2, and VOCs) for the major sources within New Mexico, Kansas, Oklahoma, and Texas can be found in Appendix A.

The 2017 NEI data are broken down into the following emission source categories:

- Solvents – consumer and commercial solvent use, degreasing, dry cleaning, graphic arts, industrial surface coating and solvent use, and non-industrial surface coating
- Mobile sources – aircraft, commercial marine vessels, locomotives, non-road equipment, and on-road vehicles
- Industrial processes – cement manufacturing, chemical manufacturing, ferrous metals, mining, NEC, nonferrous metals, oil and gas production, petroleum refineries, pulp and paper, and storage and transfer
- Fires – agricultural field burning, prescribed burning, and wildfires
- Biogenic sources – vegetation and soil
- Fuel combustion – institutional, electric generation, industrial boilers, internal combustion engines (ICEs), and residential (for biomass, coal, natural gas, oil)
- Agriculture – crops and livestock dust, fertilizer application, and livestock waste

- Dust – construction dust, paved road dust, and unpaved road dust.

The figures below show the 2017 NEI VOC, NO_X, CO, PM_{10}, $PM_{2.5}$, and SO_2 emissions for the states of New Mexico, Texas, Oklahoma, and Kansas, showing the estimated percentage of total emissions from each of the applicable emission source categories above.

3.1 2017 NATIONAL EMISSIONS INVENTORY DATA

3.1.1 VOLATILE ORGANIC COMPOUND EMISSIONS

The 2017 NEI VOC emissions for the states of New Mexico, Texas, Oklahoma, and Kansas are presented in Figure 2, which shows the estimated percentage of total VOC emissions from biogenic sources, fires, industrial processes, mobile sources, and solvents (EPA 2021).

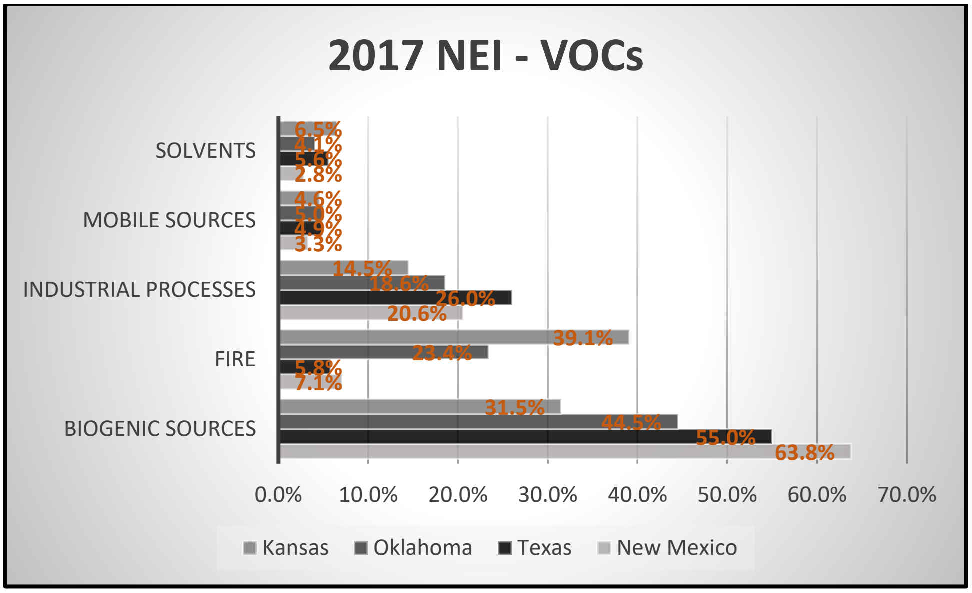


Figure 2. 2017 NEI - VOCs

The 2017 NEI data for the BLM New Mexico portion of the San Juan Basin (San Juan, Rio Arriba, Sandoval, and McKinley Counties) indicate that biogenic sources and fires account for 39.5% and 12.9% of total VOC emissions, respectively, in the area (EPA 2021). Industrial processes account for 40.5%, of which approximately 98.4% are from oil and gas production.

The 2017 NEI data for the BLM New Mexico portion of the Permian Basin (Eddy, Lea, Chaves, and Roosevelt Counties) indicate that biogenic sources and fires account for 45.9% and 1.4% of total VOC emissions, respectively, in the area (EPA 2021). Industrial processes account for 48.3%, of which approximately 99.0% are from oil and gas production.

3.1.2 NITROGEN OXIDES EMISSIONS

The 2017 NEI NO_x emissions for the states of New Mexico, Texas, Oklahoma, and Kansas are presented in Figure 3, which shows the estimated percentage of total NO_x emissions from fuel combustion, biogenic sources, fires, industrial processes, and mobile sources (EPA 2021).

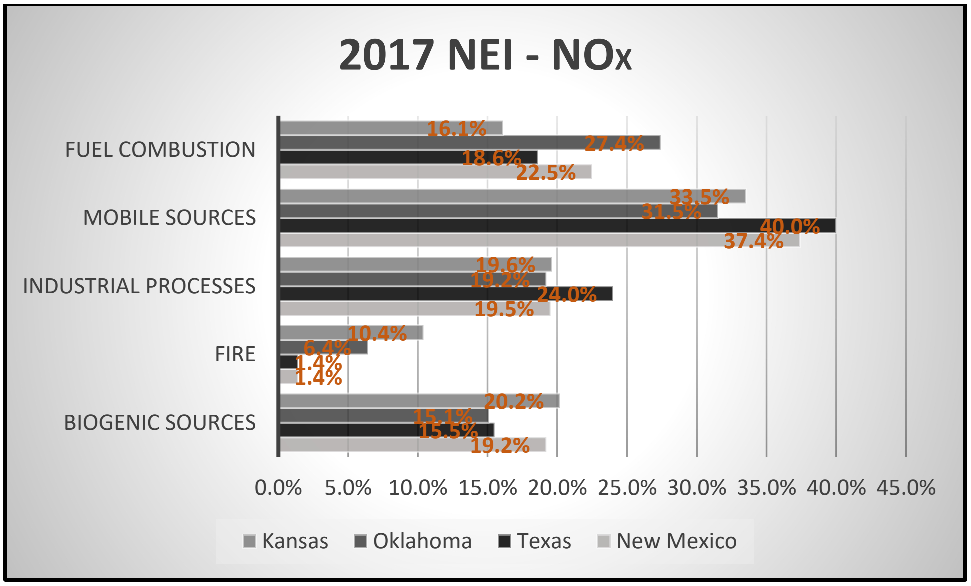


Figure 3. 2017 NEI - NO_X

The 2017 NEI data for the BLM New Mexico portion of the San Juan Basin (San Juan, Rio Arriba, Sandoval, and McKinley Counties) indicate that fuel combustion and mobile sources account for 38.3% and 18.0% of total NO_x emissions, respectively, in the area (EPA 2021). Industrial processes account for 34.2%, of which approximately 99.3% are from oil and gas production.

The 2017 NEI data for the BLM New Mexico portion of the Permian Basin (Eddy, Lea, Chaves, and Roosevelt Counties) indicate that fuel combustion and mobile sources account for 28.5% and 17.9% of total NO_x emissions, respectively, in the area (EPA 2021). Industrial processes account for 39.3%, of which approximately 98.0% are from oil and gas production.

3.1.3 CARBON MONOXIDE EMISSIONS

The 2017 NEI CO emissions for the states of New Mexico, Texas, Oklahoma, and Kansas are presented in Figure 4, which shows the estimated percentage of total CO emissions from fuel combustion, biogenic sources, fires, industrial processes, and mobile sources (EPA 2021).

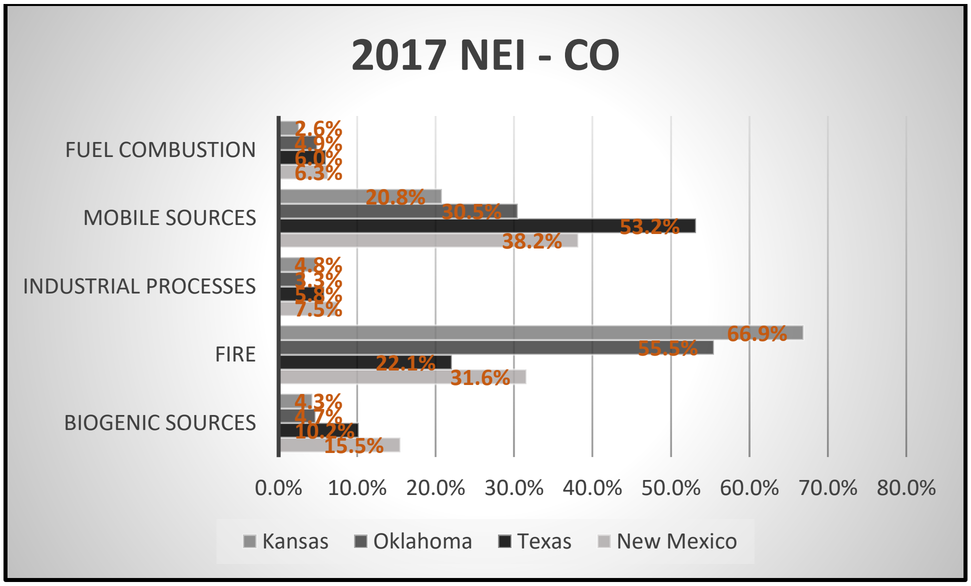


Figure 4. 2017 NEI - CO

The 2017 NEI data for the BLM New Mexico portion of the San Juan Basin (San Juan, Rio Arriba, Sandoval, and McKinley Counties) indicate that fires and mobile sources account for 46.3% and 21.2% of total CO emissions, respectively, in the area (EPA 2021). Industrial processes account for 16.5%, of which approximately 99.9% are from oil and gas production.

The 2017 NEI data for the BLM New Mexico portion of the Permian Basin (Eddy, Lea, Chaves, and Roosevelt Counties) indicate that fires and mobile sources account for 12.8% and 33.9% of total CO emissions, respectively, in the area (EPA 2021). Industrial processes account for 20.3%, of which approximately 97.7% are from oil and gas production.

3.1.4 PARTICULATE MATTER

The 2017 NEI PM_{10} and $PM_{2.5}$ emissions for the states of New Mexico, Texas, Oklahoma and Kansas are presented in Figure 5 and Figure 6, which show the estimated percentage of total VOC emissions from dust sources, fuel combustion, agriculture, fires, industrial processes, and mobile sources (EPA 2021).

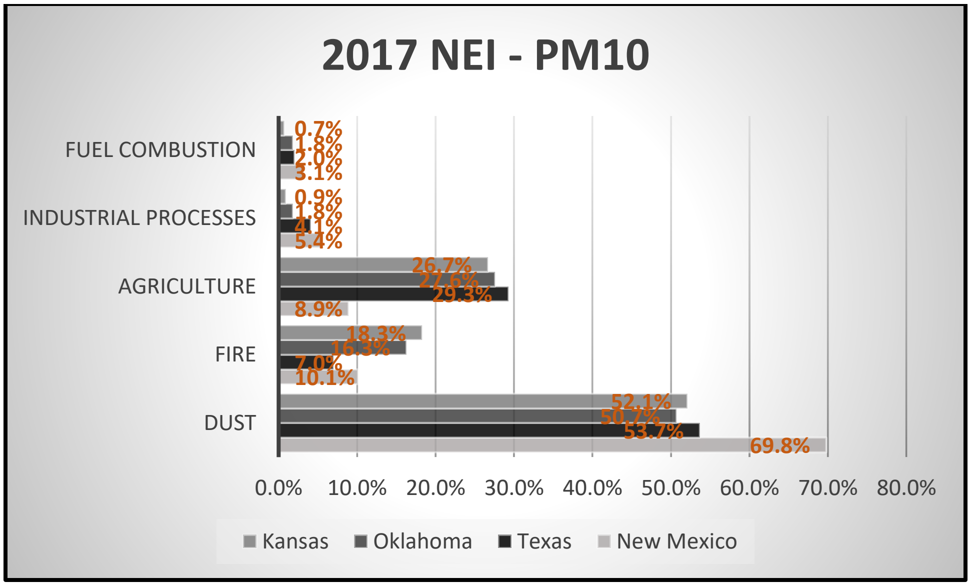


Figure 5. 2017 NEI - PM_{10}

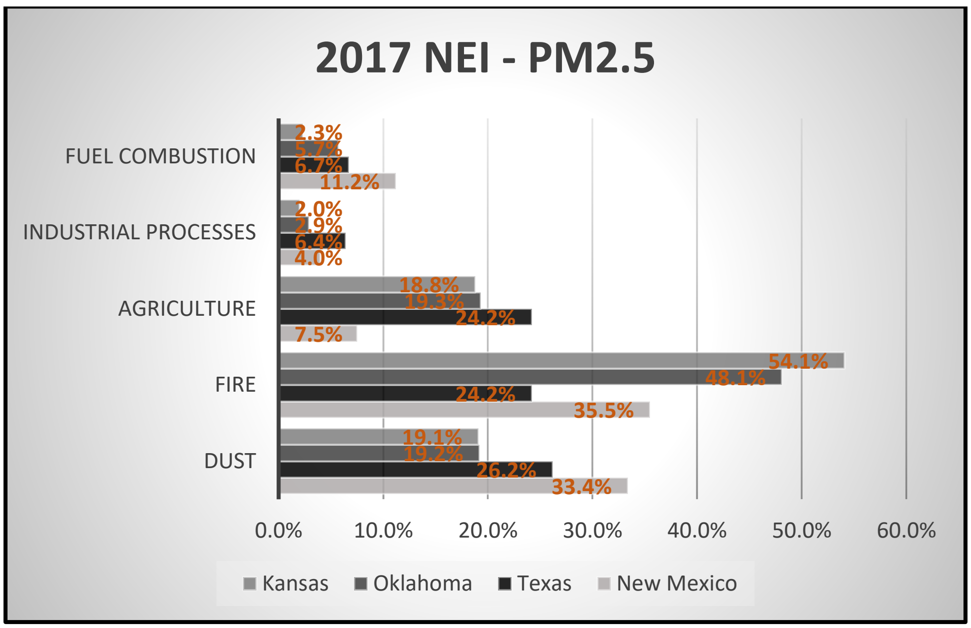


Figure 6. 2017 NEI - $PM_{2.5}$

The 2017 NEI data for the BLM New Mexico portion of the San Juan Basin (San Juan, Rio Arriba, Sandoval, and McKinley Counties) indicate that dust, fires, and fuel combustion account for 66.0%, 17.5%, and 6.0% of total PM_{10} emissions, respectively, in the area (EPA 2021). Dust, fires, and fuel combustion account for 24.8%, 48.2%, and 16.2%, respectively, of total $PM_{2.5}$ emissions.

The 2017 NEI data for the BLM New Mexico portion of the Permian Basin (Eddy, Lea, Chaves, and Roosevelt Counties) indicate that dust and agriculture account for 70.0% and 13.9% of total PM_{10} emissions, respectively, in the area (EPA 2021). Industrial processes account for 10.3%, of which approximately 7.0% are from oil and gas production. Dust and agriculture account for 45.1% and 15.9%, respectively, of total $PM_{2.5}$ emissions. Industrial processes account for 12.1%, of which approximately 33.2% are from oil and gas production.

3.1.5 SULFUR DIOXIDE EMISSIONS

The 2017 NEI SO_2 emissions for the states of New Mexico, Texas, Oklahoma, and Kansas are presented in Figure 7, showing the estimated percentage of total SO_2 emissions from fuel combustion, fires, industrial processes, and mobile sources (EPA 2021).

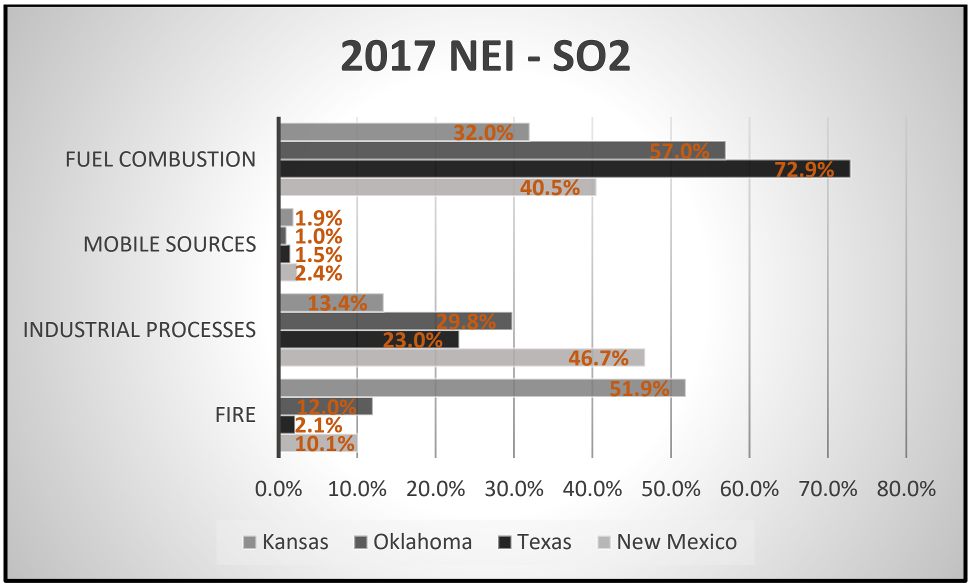


Figure 7. 2017 NEI - SO_2

The 2017 NEI data for the BLM New Mexico portion of the San Juan Basin (San Juan, Rio Arriba, Sandoval, and McKinley Counties) indicate that fuel combustion and fires account 84.0% and 9.7% of total SO_2 emissions, respectively, in the area (EPA 2021). Industrial processes account for 5.3%, of which approximately 85.6% come from oil and gas production.

The 2017 NEI data for the BLM New Mexico portion of the Permian Basin (Eddy, Lea, Chaves, and Roosevelt Counties) indicate that fuel combustion and fires account for 4.0% and 1.0% of total SO_2 emissions, respectively, in the area (EPA 2021). Industrial processes account for 94.3%, of which approximately 98.3% are from oil and gas production.

3.1.6 LEAD EMISSIONS

According to the 2017 NEI, aircraft account for 89.9% of the lead emissions in New Mexico. In Texas, 76.9% of the lead emissions are from aircraft. In Oklahoma, 55.2% of lead emissions are from aircraft and 14.3% are from waste disposal. In Kansas, 89.7% of lead emissions are from aircraft (EPA 2021).

4 HAZARDOUS AIR POLLUTANTS

Currently there are 187 specific pollutants and chemical groups known as hazardous air pollutants (HAPs). The list has been modified over time. HAPs are chemicals or compounds that are known or suspected to cause cancer or other serious health effects, such as compromises to immune and reproductive systems, birth defects, developmental disorders, or adverse environmental effects and may result from either chronic (long-term) and/or acute (short-term) exposure. CAA Sections 111 and 112 establish mechanisms for controlling HAPs from stationary sources, and the EPA is required to control emissions of the 187 HAPs. The U.S. Congress amended the federal CAA in 1990 to address a large number of air pollutants that are known to cause or may reasonably be anticipated to cause adverse effects on human health or adverse environmental effects.

Ambient air quality standards do not exist for HAPs; however, the CAA requires control measures for HAPs. Mass-based emissions limits and risk-based exposure thresholds have been established as significance criteria to require maximum achievable control technologies (MACT) under the EPA promulgated National Emissions Standards for Hazardous Air Pollutants (NESHAPs) for 96 industrial source classes. NESHAPs are issued by the EPA to limit the release of specified HAPs from specific industrial sectors. These standards are technology based, meaning that they represent the MACT that are economically feasible for an industrial sector.

NESHAPs for Oil and Natural Gas Production and Natural Gas Transmission and Storage were published by the EPA on June 17, 1999. These NESHAPs were directed toward major sources and intended to control benzene, toluene, ethyl benzene, mixed xylenes (BTEX), and n-hexane. An additional NESHAP for Oil and Natural Gas Production Facilities directed toward area sources was published on January 3, 2007, and specifically addresses benzene emissions from triethylene glycol dehydrations units. The EPA issued a final rule revising the NESHAP rule effective October 15, 2012. The final rule includes revisions to the existing leak detection and repair requirements and established emission limits reflecting MACT for currently uncontrolled emission sources in oil and gas production and natural gas transmission and storage (Federal Register 77(159):49490–49600).

The EPA NESHAPs that are most likely to have applicability to oil and gas operations are as follows (in addition to the NESHAPs common/general provisions):

- NESHAP Subpart HH - National Emission Standard for Hazardous Air Pollutants from Oil and Natural Gas Production Facilities
- NESHAP Subpart ZZZZ - National Emission Standard for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines

Note that several of the NSPS that are potentially applicable to oil and gas operations (listed in Section 2) also regulate emissions of VOCs, a component of which include HAP emissions. While the NSPS is not designed to directly regulate HAP emissions, control of VOCs results in the co-benefit of HAP reductions.

The CAA defines a major source for HAPs to be one emitting 10 tpy of any single HAP or 25 tpy of any combination of HAPs. Under state regulations, a construction or operating permit may be required for any major source, though some exceptions apply. In New Mexico, these regulations are 20.2.70 and NMAC 20.2.73; in Texas, the regulation is 30 Texas Administrative Code (TAC) § 122; in Kansas, the regulation is Kansas Administrative Regulations (K.A.R.) 28-19-500; and in Oklahoma, the regulation is Oklahoma Register 252-100-7. Within its definition of a major source in the above-referenced regulations, the state of New Mexico includes the following language:

> *…hazardous emissions from any oil or gas exploration or production well (with its associated equipment) and hazardous emissions from any pipeline compressor or pump station shall not be aggregated with hazardous emissions from other similar units, whether or not such units are in a contiguous area or under common control, to determine whether such units or stations are major sources…*

In other words, in determining a major source, each oil and gas exploration and production well must be considered singularly. Kansas, Texas, and Oklahoma regulations include similar language.

The state of New Mexico incorporates federal NESHAPs for pollutants through updates to NMAC 20.2.78 , which adopts 40 C.F.R. Part 61, and federal NESHAPs for source categories through updates to NMAC 20.2.82, which adopts 40 C.F.R. Part 63. Similarly, Texas incorporates federal NESHAPs for both 40 C.F.R. 61 and 40 C.F.R. 63 through updates to 30 TAC § 113. Kansas incorporates federal NESHAPs by adopting 40 C.F.R. 61 through updates to K.A.R. 28-19-735 and incorporates NESHAP source categories at 40 C.F.R. 63 through updates to K.A.R. 28-19-750. Oklahoma incorporates both 40 C.F.R. 61 and 40 C.F.R. 63 through Oklahoma Register 252-100-41-2 and the Oklahoma Administrative Code Appendix Q.

4.1 AIR TOXICS SCREENING ASSESSMENT

The Air Toxics Screening Assessment (AirToxScreen) is EPA's ongoing review of air toxics in the United States. The EPA developed AirToxScreen as a screening tool for state, local, and tribal air agencies. AirToxScreen's results help the EPA and other agencies identify which pollutants, emission sources, and places they may wish to study further to better understand any possible risks to public health from air toxics. AirToxScreen is the successor to the previous National Air Toxics Assessment, or NATA. In March 2022, EPA released the results of its 2017 AirToxScreen.

AirToxScreen calculates concentration and risk estimates from a single year's emissions data using meteorological data for that same year. The risk estimates assume a person breathes these emissions each year over a lifetime (or approximately 70 years). AirToxScreen then provides quantitative estimates of potential cancer risk and five classes of non-cancer hazards (grouped by organ/system: immunological, kidney, liver, neurological, and respiratory) associated with chronic inhalation exposure to real-world toxics. The 2017 AirToxScreen assessment includes emissions, ambient concentrations, and exposure estimates for about 180 of the 188 CAA air toxics plus diesel particulate matter (diesel PM). For about 140 of these air toxics (those with health data based on long-term exposure), the assessment estimates cancer risks, from the potential for noncancer health effects, or both. This includes noncancer health effects for diesel PM.

AirToxScreen potential cancer risk values represent statistical probabilities of developing cancer over a lifetime. AirToxScreen non-cancer hazards are expressed as a ratio of an exposure concentration to a reference concentration (RfC) associated with observable adverse health effects (i.e., a hazard quotient). "For a given air toxic, exposures at or below the RfC (i.e., hazard quotients are 1 or less) are *not* likely to be associated with adverse health effects. As exposures increase above the RfC (i.e., hazard quotients are greater than 1), the potential for adverse effects also increases" (EPA 2018).

AirToxScreen can answer many questions including the following (EPA 2018):

- Which air toxics pose the greatest potential risk of cancer or adverse non-cancer effects across the entire United States?

- Which air toxics pose the greatest potential risk of cancer or adverse non-cancer effects in certain areas of the United States?
- Which air toxics pose less, but still significant, potential risk of cancer or adverse non-cancer effects across the entire United States?
- When risks from long-term inhalation exposures to all outdoor air toxics are considered together, how many people could experience a lifetime cancer risk greater than levels of concern (e.g., 1-in-1 million or 100-in-1 million)?
- When considering potential adverse non-cancer effects from long-term exposures to all outdoor air toxics together for a given target organ or system, how many people could experience exposures that exceed the reference levels intended to protect against those effects (i.e., a hazard quotient greater than 1)?

AirToxScreen can be used as a tool to identify places of interest for further study, to get a starting point for local assessments, and to inform monitoring programs. For example, communities use AirToxScreen to determine the data and research that are needed to better assess their local risk from air toxics. Communities have found that using AirToxScreen helps inform and empower citizens to make local decisions about their community's health.

It is important to note that AirToxScreen focuses solely on exposures from inhalation of outdoor ambient air. The AirToxScreen framework does not address inhalation from indoor ambient air, estimate human exposure to chemicals via ingestion or through dermal contact, or account for exposures that may take place via other mechanisms. In addition, AirToxScreen results should not be used:

- as a definitive means to pinpoint specific risk values within a census tract,
- to characterize or compare risks at local levels (such as between neighborhoods),
- to characterize or compare risks between states,
- to examine trends from one assessment to another,
- as the sole basis for developing risk reduction plans or regulations,
- as the sole basis for determining appropriate controls on specific sources or air toxics, or
- as the sole basis to quantify benefits of reduced air toxic emissions (EPA 2018).

In addition, although AirToxScreen reports results at the census tract level, average risk estimates are far more uncertain at this level of spatial resolution than at the county or state level. To analyze air toxics in smaller areas, such as census blocks or in suspected "hotspots," other tools such as site-specific monitoring and local-scale assessments should be used (EPA 2018). AirToxScreen results are best used to focus on patterns and ranges of risks across the country.

Reference concentrations, known as RfC, are indicators defined by the EPA as the daily inhalation concentrations at which no long-term adverse health impacts are expected. Short-term (1-hour) HAP concentrations will be compared with acute Reference Exposure Levels (RELs). RELs are defined as concentrations at or below which no adverse health effects are expected (California Office of Environmental Health Hazard Assessment 2019). The primary air toxics of concern for oil and gas operations are the BTEX compounds (benzene, toluene, ethylbenzene, and xylene), formaldehyde, and n-hexane.

Total cancer risk for the state of New Mexico (20.27 cases per million) was less than that of the United States (28.68 cases per million) (Table 5). In addition, all five non-cancer hazard quotient values were consistently lower in the state of New Mexico (immunological: 0.01; kidney: 0.003; liver: 0.008; neurological: 0.02; and respiratory: 0.24) than the national values (immunological: 0.02, kidney: 0.01; liver: 0.01; neurological: 0.03; and respiratory: 0.36).

At the county level, all eight counties (Chaves, Eddy, Lea, McKinley, Rio Arriba, Sandoval, San Juan, and Roosevelt) had cancer risk values and total hazard quotients less than those of the United States, with all total hazard quotients reported being less than 1 (<1.0).

Table 5. NATA Data for the United States, Texas, Oklahoma, Kansas, New Mexico, and Eight Counties in New Mexico

Location	Population	Total Cancer Risk (per million)	Total Hazard Quotients				
			Immunological	Kidney	Liver	Neurological	Respiratory
United States	312,566,557	28.6760	0.0199	0.0094	0.0137	0.0349	0.3625
Texas	25,145,250	**31.3290**	0.0145	0.0077	0.0120	0.0286	0.3530
Oklahoma	3,750,989	**28.9573**	0.0145	0.0045	0.0099	0.0222	**0.3932**
Kansas	2,853,098	24.7605	0.0183	0.0093	**0.0148**	0.0261	0.3323
New Mexico	2,059,160	20.2683	0.0107	0.0030	0.0081	0.0189	0.2420
Chaves Co.	65,645	19.4500	0.0081	0.0016	0.0067	0.0172	0.2294
Eddy Co.	53,828	21.4123	0.0120	0.0014	0.0065	0.0149	0.2393
Lea Co.	64,725	20.2657	0.0107	0.0014	0.0066	0.0146	0.2268
McKinley Co.	71,492	12.1178	0.0038	0.0006	0.0054	0.0128	0.1326
Rio Arriba Co.	40,246	13.5508	0.0038	0.0004	0.0054	0.0142	0.1524
Sandoval Co.	131,561	20.2920	0.0119	0.0036	0.0086	0.0210	0.2392
San Juan Co.	130,043	17.5695	0.0068	0.0015	0.0063	0.0165	0.2875
Roosevelt	18,844	15.46	0.0048	0.0007	0.0060	0.0142	0.1650

Source: EPA (2018)

The eight counties in table are Chaves, Eddy, Lea, McKinley, Rio Arriba, Sandoval, San Juan, and Roosevelt Counties, where parcels are regularly nominated for BLM New Mexico Quarterly Oil and Gas Lease Sales.

Data for the United States, New Mexico, and eight counties in New Mexico. Total cancer risks and five total hazard quotients (immunological, kidney, liver, neurological, and respiratory) values are reported. Total cancer risk and hazard quotients at the county level in bold are those that are greater than the values for the state of New Mexico.

Detailed county and census-tract level results are reported in Appendix B, grouped according to BLM District Office/Field Office boundaries, with Pecos District counties (Chaves, Eddy, and Lea) grouped together, and Rio Puerco Field Office and Farmington Field Office (FFO) counties (McKinley, Rio Arriba, Sandoval, San Juan, and Roosevelt) grouped together.

4.2 HYDROGEN SULFIDE

Hydrogen sulfide (H_2S) is a colorless flammable gas with a rotten egg smell that is a naturally occurring byproduct of oil and gas development in some areas, including the New Mexico portion of the Permian Basin. H_2S is both an irritant and a chemical asphyxiant with effects on both oxygen utilization and the central nervous system. Its health effects can vary depending on the level and duration of exposure. Effects may range from eye, nose, and throat irritation to dizziness, headaches, and nausea. High concentrations can cause shock, convulsions, inability to breathe, extremely rapid unconsciousness, coma, and death. Effects can occur within a few breaths, and possibly a single breath.

H_2S was originally included in the list of Toxic Air Pollutants defined by Congress in the 1990 amendments to the CAA. It was later determined that H_2S was included through a clerical error, and it was removed by Congress from the list. H_2S was addressed under the accidental release provisions of the CAA. Congress also tasked the EPA with assessing the hazards to public health and the environment from H_2S emissions associated with oil and gas extraction. That report was published in October 1993 (EPA 1993).

H_2S was added to the Emergency Planning and Community Right-to-Know Act list of toxic chemicals in 1993. In 1994, the EPA issued an administrative stay of reporting requirements for H_2S while further analysis was conducted. The administrative stay was lifted and Toxic Release Inventory reporting due in July 2013 for calendar year 2012 emissions required reporting of H_2S.

While there are no NAAQS for H_2S, a number of states, especially those with significant oil and gas production, have set standards at the state level. Table 6 summarizes these standards for states under BLM NMSO jurisdiction.

Table 6. State Ambient Air Quality Standards for H_2S

State	Standard	Averaging time	Remarks
Kansas	None	N/A	N/A
Oklahoma	200 ppb (0.2 ppm)	24 hour	N/A
New Mexico	0.010 ppm (10 ppb)	1 hour(1)	Statewide except Pecos-Permian Basin Intrastate Air Quality Control Region*
	0.100 ppm (100 ppb)	0.5 hour(2)	Pecos-Permian Basin Intrastate Air Quality Control Region
	0.030 ppm (30 ppb)	0.5 hour	Within municipal boundaries and within 5 miles of municipalities with population >20,000 in Pecos-Permian Basin Air Quality Control Region

State	Standard	Averaging time	Remarks
Texas	0.08ppm (80 ppb)	0.5 hour	If downwind concentration affects a property used for residential business or commercial purposes
	0.12 ppm (120 ppb)	0.5 hour	If downwind concentration affects only property not normally occupied by people

Source: Skrtic (2006)

* The Pecos-Permian Basin Intrastate Air Quality Control Region is composed of Quay, Curry, De Baca, Roosevelt, Chaves, Lea, and Eddy Counties in New Mexico.

(1) Pecos-Permian Basin intrastate air quality control region has a 0.5-hour standard of 0.10 ppm.

(2) Not to be exceeded more than once per year.

NMED has no routine monitors for H_2S. However, a one-time study in 2002 (Skrtic 2006) sheds some light on the levels that can be expected near oil and gas facilities. These readings are averaged over 3-minute periods so are not comparable with the standard which has longer averaging periods. The New Mexico data indicate that ambient concentrations of H_2S at the sampling locations, which included both oil and gas facilities and sites without oil and gas facilities, are at least an order of magnitude greater than 0.11 to 0.33 ppb, which are the ambient levels of H_2S that can be expected in urban areas. The ambient levels recorded at the two sites without expected sources of H_2S—Indian Basin Hilltop, no facility; and Carlsbad City Limits, Tracy-A—both averaged 7 ppb, indicating that H_2S concentrations in this part of New Mexico are higher than normal urban background levels (Skrtic 2006).

H_2S levels sampled at flaring, tank storage, and well drilling sites, averaging from approximately 100 to 200 ppb, are significantly elevated compared with normal background levels, and compared with usual background H_2S concentrations in this area of New Mexico (Skrtic 2006). While these concentrations generally produce a nuisance due to odors that may translate into headaches, nausea, and sleep disturbances if exposure is constant, one study found central nervous system, respiratory system, and ear, nose, and throat symptoms associated with annual average H_2S levels ranging from 7 to 27 ppb (Skrtic 2006). Overall, the data show that concentrations of H_2S vary widely, even at similar facilities: at one compressor/dehydrator, the average concentration over the course of monitoring was 4 ppb, while at another, the average was 1,372 ppb. The data further demonstrate that H_2S is present, often at elevated levels, at oil and gas facilities (Skrtic 2006).

Table 7. Summary of Monitoring Data from New Mexico Study

Facility Type	H_2S Concentration Measured at Monitoring Site (ppb)	
	Range	Average
Indian Basin hilltop, no facility	5–8	7
Indian Basin compressor station	3–9	6
Indian Basin active well drilling site	7–190	114
Indian Basin flaring, production, and tank storage site	4–1,200	203
Marathon Indian Basin refining and tank storage site	2–370	16

Facility Type	H_2S Concentration Measured at Monitoring Site (ppb)	
	Range	Average
Carlsbad city limits, near 8 to 10 wells and tank storage sites	5–7	6
Carlsbad city limits, Tracy-A	5–8	7
Compressor station, dehydrators – Location A	4–5	4
Compressor station, dehydrators – Location B	2–15,000	1,372
Huber flare/dehydrating facility	4–12	77
Snyder oil well field	2–5	4
Empire Abo gas processing plant	1–1,600	300
Navajo oil refinery	3–14	7–8

Source: Skrtic (2006)

In Oklahoma, routine monitoring downwind of two refineries in Tulsa showed H_2S levels that were within state standards but above normal background levels. The levels of H_2S in both neighborhoods, although not very high, are nevertheless above the EPA's RfC of 1.4 ppb, and are elevated well above normal background levels of 0.11 to 0.33 ppb. It is possible that continuous exposure to these levels poses health risks. While the Oklahoma DEQ is monitoring H_2S levels, there is no concurrent community health or exposure study investigating the health effects of chronic exposure to these levels of H_2S (Skrtic 2006). In Texas, which has 12 routine monitors, H_2S levels generally ranged from 0.1 to 5 ppb. One monitor at a compressor station, however, showed frequent levels in excess of the state standard of 0.8 ppm (Skrtic 2006). In December 2005, the last month for which the data have been validated by the TCEQ, 20% of the hourly readings exceeded the state standard of 0.8 ppm. Chronic exposure to such levels, generally considered a nuisance due to odor, has also been shown to adversely affect human health (Skrtic 2006).

5 METHODOLOGY AND ASSUMPTIONS FOR ANALYSIS OF AIR RESOURCES

Air resource impacts can be analyzed on a number of different levels. First and most basic is to compare monitored pollutant levels with NAAQS. This applies only to criteria pollutants and provides a basis for determining whether the emissions of any specific pollutant are significant in a local area. Secondly, and necessary before further analysis can be done, is an estimate of actual emissions, or an emissions inventory. This may be done for all emissions in a geographic area and for a project to provide a comparison. The EPA completes an NEI (see Section 3.1) at the county level every 3 years, which provides a baseline for determining whether project emissions will cause a substantial increase in emissions or materially contribute to potential adverse cumulative air quality impacts. Finally, if impacts are anticipated to be significant, it may be necessary to apply air quality modeling to analyze the extent and geographic distribution of impacts.

Traditional air quality modeling generally falls into three categories: 1) near-field dispersion modeling is applied to criteria pollutants, HAPs, and AQRVs where a small to medium number of sources are involved to cover an area within 50 kilometers (km) of a proposed project; 2) far field or transport modeling is used to provide regional assessments of cumulative and incremental impacts at distances greater than 50 km; 3) photochemical modeling may be used for large-scale projects with a large number of sources or with complex issues including O_3 and secondary particulate impacts.

5.1 EMISSION INVENTORIES, STUDIES, AND MODELING

An emissions inventory is a database that lists, by source, the amount of air pollutants discharged into the atmosphere during a year or other time period. Governments use emission inventories to help determine significant sources of air pollutants and to target regulatory actions. Emissions inventories are an essential input to mathematical models that estimate air quality. The effect on air quality of potential regulatory actions can be estimated by applying estimated emissions reductions to emissions inventory data in air quality models.

Emission trends over time can be established with periodic updates of the emissions inventory. Inventories also can be used to raise public awareness regarding sources of pollution. An emissions inventory includes estimates of the emissions from various pollution sources in a geographical area. It should include all pollutants associated with the air quality problems in the area. For example, an emissions inventory to support the management of ground-level O_3 should include sources of NO_x and VOCs (EPA 2020b). Emission inventories are performed to determine the current state of the atmosphere, contribute to determining a future state of the atmosphere, aid decision-makers in policy and regulatory guidance, and determine emission controls. The most recent emission inventory relative to BLM New Mexico operations (Permian and San Juan Basins) was completed in 2017 for base year 2014. Other emission inventories, studies, and modeling years include 2005, 2007, 2009, and 2013.

5.1.1 2014 WESTERN STATES AIR RESOURCES COUNCIL–WESTERN REGIONAL AIR PARTNERSHIP EMISSIONS INVENTORY

The Western States Air Resources Council–Western Regional Air Partnership (WESTAR-WRAP) conducted an oil and gas emissions inventory report for base year 2014 to further clarify the contributions of oil and gas activities to human-caused emissions within the Permian and San Juan Basins (Ramboll Environ 2017). The inventory included the counties of Chaves, Eddy, Lea, and Roosevelt for the Permian Basin. The inventory included data from not only the New Mexico counties of McKinley, Rio Arriba, Sandoval, San Juan, and Valencia but also Archuleta and La Plata in Colorado. For the purposes of our analysis, we only bring forth emissions from Eddy, Lea, Chaves, Roosevelt, Rio Arriba, San Juan, McKinley, and Sandoval Counties for reporting and comparison in Table 8.

Table 8. 2014 WESTAR-WRAP Inventory Emissions

Basin/Counties	Emissions (metric tons)	
Permian Basin (Chavez, Eddy, Lea and Roosevelt Counties)	**NO_X**	**VOCs**
WESTAR-WRAP 2014 oil and gas sources	30,351	121,644
San Juan Basin (San Juan, Rio Arriba, McKinley, Sandoval Counties)	**NO_X**	**VOCs**
WESTAR-WRAP 2014 oil and gas sources	44,433	86,173

Source: Ramboll Environ (2017)

Only precursor pollutants to O_3 formation compared in this analysis (NO_x and VOC).

The WESTAR-WRAP data show the following:

In the New Mexico Permian Basin, non-point and point sources of oil and gas are shown to contribute 11,790 and 18,561 tpy respectively of the 30,351 total tpy of human-made NO_x emissions. The inventory revealed that the major oil and gas sources (point and non-point sources) of NO_x emissions are attributed to point source compressor engines (33%), midstream unclassified sources (29%), drill rigs (16%), artificial lifts (13%), fracking (4%), and non-point heaters (3%), as well as other sources totaling approximately 2% of non-point and point emission sources.

In the New Mexico Permian Basin, non-point and point sources of oil and gas are shown to contribute 110,480 and 11,164 tpy, respectively, of the total 121,644 tpy of human-made VOC emissions. The inventory revealed that the major oil and gas sources of VOCs emissions are attributed to oil tanks (58%), midstream unclassified sources (7%), venting-blowdowns (7%), pneumatic devices (7%), and oil well truck loading (6%), as well as other sources representing approximately 15% of non-point and point VOC emission sources.

In the New Mexico San Juan Basin, non-point sources of oil, gas, and coalbed CH_4 wells are shown to contribute 33,435 tpy of the total 44,433 tpy of human-made NO_x emissions. These major categories of non-point NO_x emissions are attributed to nonpoint compressor engines (88%), water pump engines (6.9%), non-point heaters (2.4%), and artificial lift devices (1.9%), as well as other sources representing approximately 0.8% of non-point NO_x emission sources.

In the New Mexico San Juan Basin, non-point sources of oil, gas, and coalbed CH_4 wells are shown to contribute 79,363 tpy of the total 86,173 tpy of human-made VOC emissions. These major categories of non-point VOCs emissions are attributed to pneumatic devices (32%), non-point compressor engines (18.5%), non-point fugitives (14.8%), pneumatic pumps (12.7%), and dehydrators (9.7%), as well as other sources representing approximately 12.3% of non-point VOC emission sources (Ramboll Environ 2017).

5.1.2 2008 OZONE STUDY

In 2013, the Western Regional Air Partnership (WRAP) completed a regional technical analysis for O_3 (WestJump) that includes information about O_3 impacts and sources that contribute to the formation of O_3 for calendar year 2008. The analysis demonstrated that the largest contributor to O_3 concentrations in the western United States was international transport and stratospheric O_3. State-to-state O_3 transport was important as well. Since O_3 is not directly emitted, it can't be evaluated like other pollutants. O_3 can travel great distances, affecting air quality and public health regionally, and all states contribute to some degree to all other states O_3 issues. However, those with higher O_3 precursor emissions contribute more, generally. For example, New Mexico sources significantly contribute to elevated O_3 concentrations in Texas, Arizona, and Colorado. Texas is a significant contributor to elevated O_3 in Oklahoma, Louisiana, New Mexico, Missouri, and Arizona. Kansas sources significantly contribute to elevated O_3 in Missouri and Texas, while Oklahoma sources significantly contribute to elevated O_3 in Missouri, Texas, and New Mexico (ENVIRON et al. 2013). The term significant in this context is based on the degree to which an upwind state's anthropogenic emissions contribute to a downwind state's average design value. Emission contributions from an upwind state are assumed to be significant if the contribution from the upwind state's emissions results in impacts to a nonattainment area (with an average design value above the NAAQS) in excess of 1% of the NAAQS.

The WestJump analysis also provides information about $PM_{2.5}$ impacts and contributing sources for calendar year 2008. Like O_3, $PM_{2.5}$ can travel great distances and interstate transport is significant. New Mexico significantly contributes to annual $PM_{2.5}$ exceedances in Arizona; Texas significantly contributes to exceedances in Arkansas, Missouri, Mississippi, Illinois, and Alabama; Oklahoma significantly contributes to exceedances in Arkansas and Missouri; and Kansas significantly contributes to exceedances in Iowa, Missouri, Illinois, Arkansas, and Wisconsin. For the 24-hour $PM_{2.5}$ standard, New Mexico significantly contributes to exceedances in California, Texas and Oklahoma significantly contribute to exceedances in Iowa, and Kansas significantly contributes to exceedances in Iowa and Wisconsin (ENVIRON et al. 2013).

5.1.3 PREVIOUS STUDIES

Previous emissions inventories were conducted for New Mexico in 2007 and 2009, and a photochemical modeling analysis was completed for the Four Corners Air Quality Task Force (FCAQTF) in 2009. These inventories and modeling are discussed in more detail in the 2020 Air Resources Technical Report (BLM 2021d).

5.1.4 PLANNED MODELING STUDIES

An update to previous photochemical grid modeling studies is in the planning phase as part of the New Mexico Ozone Attainment Initiative, which will use 2014 Base Year Emission Inventory data and develop projections for future year 2023. The modeling study will be conducted by enhancing the WRAP/Western Air Quality Study (WAQS) 2014 modeling platform to use a 4-km grid resolution domain covering New Mexico and surrounding areas, especially the oil and gas production regions in the Permian and San Juan Basins (Ramboll Environ and Westar 2020).

5.2 PECOS DISTRICT OFFICE ATMOSPHERIC AND PHOTOCHEMICAL GRID MODELING

An Air Resources Technical Support Document (ARTSD) by URS Corporation (URS) (2013) was prepared to report the potential air quality impacts resulting from the Reasonable Foreseeable Development (RFD) scenario. This effort included atmospheric dispersion and photochemical grid modeling to predict concentrations of specific pollutants in and around the CFO (in which most of the Pecos District oil and gas activity occurs). The results of ARTSD analysis indicate that air quality impacts from the RFD scenario, while noticeable, are generally acceptable. Most predicted criteria pollutant concentrations are well below the NAAQS throughout the extensive modeling domains included in this analysis. While no exceedances of NAAQS were predicted from the modeling of federal wells associated with the RFD scenario (6,400 wells), consideration of the entire RFD scenario (16,000 wells) and other reasonably foreseeable future actions (i.e., cumulative impacts) in the ARTSD included predictions of pollutant concentrations approaching or exceeding the NAAQS (for O_3, $PM_{2.5}$ and potentially SO_2) and indicate the need for additional ambient monitoring data, refined modeling, and consideration of additional mitigation measures. Most of the areas where NAAQS would be exceeded are out of the CFO region (URS 2013). The CFO is currently undertaking a plan revision, and as part of that, is revising its RFD and air modeling.

5.3 AIR QUALITY MODELING FOR TEXAS

Numerous reports on air quality modeling projects done by and for the TCEQ, including modeling done for the several Texas county nonattainment areas, can be accessed on the Air Division website (TCEQ 2022b). The TCEQ has convened advisory groups in southeastern Texas and Dallas-Fort Worth to assist the agency in addressing photochemical modeling issues.

6 CALCULATORS OIL AND GAS DEVELOPMENT

Emissions calculators were developed by air quality specialists at the BLM National Operations Center in Denver, Colorado. The calculators use an Excel spreadsheet for computation and are based on emissions factors from the EPA and the American Petroleum Institute. The 2010 calculators were quality assured and improved by URS under contract with the BLM. Methodology for computing GHGs is documented in *The Climate Change Supplementary Information Report for the Montana, North Dakota, and South Dakota Bureau of Land Management* (URS 2010). More recently in 2013/2014, Kleinfelder West, Inc. developed a calculator for a representative oil and gas well in the western United States (Kleinfelder West, Inc. 2013). Other air pollutant computations have not yet been described in a published document but are based on methods recommended in the EPA publication AP-42 *Compilation of Air Pollutant Emissions Factors* (EPA 1995, 2006).

The calculators may be considered a type of model in that they use emissions factors, mathematical algorithms, and assumptions to arrive at some approximation of reality. However, their primary purpose is to compute an emissions inventory, which is necessary for any modeling effort. The calculators account for a number of variables, including access and construction requirements, equipment and other infrastructure needs, and expected production volumes. Because the algorithms used by the calculators to quantify emissions are based on averages and numerous assumptions must be made about construction, the calculators provide an approximation of emissions levels. Actual project emissions may be greater or less than those projected by the calculators. Emissions calculators used to estimate emissions from oil and gas development assume that wells will be hydraulically fractured; if a well is not fractured, emissions will be less than calculated.

The BLM in New Mexico has modified the calculators and assumptions for use in analyzing a single well and to more closely represent oil and gas wells in the state of New Mexico, specifically the San Juan and Permian Basins. However, it must be understood that the calculators were originally designed to make estimations of emissions at the resource management plan (RMP) level, which would result in some averaging and smoothing of assumptions. At the single well level, the uncertainty in emissions projections increases substantially.

The BLM has determined that well production typically declines over time and has assumed that declining production would result in reduced emissions over time. A production history may vary from a straight line to a hyperbolic curve. The object of decline curve analysis is to model the production history. Assuming a certain abandonment pressure or gas rate, the decline curve is used to determine the productive life of the well. Well life can vary from a few years to many decades depending on the reservoir and the year the well was drilled. Production is also dependent on the price of oil and gas. Since initial development in the San Juan Basin in the 1920s, all reservoirs have had significant reservoir pressure declines. Subsequent infill drilling will encounter reduced pressure reservoirs with limited well life spans compared with wells drilled earlier in the development of the field.

It should be noted that the calculations are based on recently drilled wells and tend to overestimate the average emissions over the lifetime of the well. It is not possible to estimate the lifespan of an individual well, nor is the calculator able to incorporate the decline curve into results, so we have computed one-time (construction, completion, workover, and reclamation) emissions and annual (operations and maintenance) emissions. However, the annual emissions do not take into account the declining production rates over the lifetime of the well.

6.1 ASSUMPTIONS

As mentioned above, the calculators account for numerous variables or inputs that are used to calculate the overall emissions of the different stages of oil and gas development. At the time of an APD, not all of these variables may be known. To populate the calculators with the different variables, the BLM CFO and BLM FFO each developed a set of assumptions pertaining to development in their respective areas. These assumptions address variables such as well depth, production, road development/maintenance, travel to and from well sites, construction times, and need for workovers. The following sections summarize the assumptions made for each field office area to populate the calculators. It should be noted that for lease sales, the BLM may use the lease sale emissions tools for well numbers and associate production estimates.

6.1.1 ASSUMPTIONS – FARMINGTON FIELD OFFICE

There are several geologic formations within the FFO boundary that are known to produce natural gas. The Fruitland Formation is the shallowest routinely produced formation at approximately 2,000 feet deep. The Dakota formation is the deepest formation routinely produced at approximately 6,000 feet deep. The Mancos Shale formation is approximately 2,500 feet deep. Several formations produce various amounts of water during the production phase of the well. The preferred method of disposing of the produced water is via an injection well drilled into the geologically isolated Entrada formation, which is approximately 7,500 feet deep. Although wells are not drilled to these precise depths, these generalized depths were used for the purpose of estimation in the emissions calculator.

Between 2015 and 2030, it is estimated that most of the oil and gas drilling in FFO will be within the Mancos Shale formation. The formation is thought to contain gas on the northern end (southern Colorado and northwestern New Mexico) and oil on the southern end (toward Gallup and Grants, New Mexico). Assumptions in the estimates account for unfavorable natural gas prices until 2019, and no gas well development in the Mancos Shale formation was expected until that time. Estimates assume that starting in 2019, approximately 100 to 200 gas wells could be drilled per year. It is likely that central collection and shipping facilities for oil will be developed too. Oil well development in the Mancos Shale formation is expected to proceed at 100 to 200 wells per year, although little development is currently occurring due to unfavorable oil prices. Recent oil well drilling has used horizontal rather than vertical wells.

BLM specialists and engineers were consulted to develop a range of values to insert into the calculator to estimate the emissions from construction, completion, interim reclamation, annual operation, and final reclamation. Pad construction, interim reclamation, and final reclamation processes are generally the same across the basin. The range of values was designed to address the requirements of about 95% of the wells developed in the San Juan Basin. Unforeseen or unpredictable events may cause approximately 5% of wells to fall outside of the range.

The calculator includes construction of a “frac pond,” as future wells in the region will most likely be accomplished with hydraulic fracturing. The calculator has options for diesel-fired or natural gas–fired drill rigs. More commonly in 2014 in the region, drill rigs were diesel-fired. Many of the well pads have associated man camps where drilling personnel are housed during well drilling. Since most pads will now accommodate more than one well, the man camps allow employees to avoid commuting during the time the wells on the pad are drilled.

The ancillary activities associated with the production phase of a well such as workovers, road maintenance, and road traffic are somewhat difficult to predict. Calculations for Mancos Shale drilling recently have assumed one well workover per year. Existing gas wells in the FFO area do not require workover on a regular schedule; 3 to 6 years between workovers is typical, and the nature of the work required during a workover is variable.

The BLM FFO and the oil and gas industry have established a road committee to identify collector roads (main travel corridors) and have established procedures to maintain collector roads as necessary. However, no regular maintenance schedule exists. Most new wells are drilled along existing resource roads that are not covered by the road committee and are maintained as needed. Although road maintenance within the FFO varies, a reasonable assumption is that the resource roads will be maintained once per year. The average length of new road required to drill a new well during the past 2 years has been 800 feet. Emissions are calculated based on this average assuming that an 800-foot resource road is maintained once per year and the maintenance work would require about 6 hours of work.

The majority of producing wells in the San Juan Basin utilize remote telemetry powered by solar panels to transmit well production data to centralized office locations. While the frequency of well site visits is not predictable, the need for well site visits during the production phase of the well is greatly reduced by the telemetry systems. Typically, a field technician will drive a light truck and will visit multiple wells per trip along an established service route. To estimate the miles required for each site visit, an additional 4.5 miles of travel along an existing driving route was added to the typical 800 feet of new road for a total of 5 miles. Emissions are calculated for weekly visits during the year for a light truck. For various servicing needs, heavy duty vehicles over 8,500 pounds gross vehicle weight rating (EPA 2020c) are required on-site during drilling and workovers. Heavy duty vehicles typically do not visit multiple sites per day. Emissions are calculated for driving 50 miles round trip for five trips per year.

The average San Juan Basin gas well produces at a rate of 100 thousand cubic feet per day (mcfd). For analysis purposes, the initial production rate is assumed to be 100 mcfd. The volume of gas and oil is normally the greatest following the completion of the well. Oil and gas production rates decline as a function of time, reservoir pressure drop, or the changing relative volumes of the produced fluids.

The FFO RMP (BLM 2003) addressed air quality based on the Air Quality Modeling Analysis Technical Report prepared by Science Applications International Corporation (SAIC) (2003). The 2003 FFO RMP modeling is considered here because it was used to characterize air quality for the purpose of land use planning, and this EA tiers to the 2003 FFO RMP. The 2003 SAIC modeling was based on the highest level of oil and gas development proposed based on the RFD and identified a potential for exceeding the NAAQS for NO_2. The alternative selected for the RMP proposed a lower level of development than that modeled. Lower levels of development and NO_x limits placed on engines have resulted in lower impacts than were modeled.

6.1.2 ASSUMPTIONS – CARLSBAD FIELD OFFICE

The CFO area of responsibility contains 28 different geologic zones that produce oil, natural gas, and water. The complex geology, variety of drilling techniques used (horizontal, vertical), uncertainty of production, and variation of the drilling time and equipment required makes it difficult to approximate the emissions for a proposed well. In order to provide a basis for extrapolation, the CFO selected a random sample of 70 wells out of a population of 1,836 wells drilled from 2007 to 2010. Since the wells included in the sample had been recently drilled at the time the study was conducted, the production data are likely an overestimate of average annual production (and therefore emissions) as production drops with the age of the well. The sample size was selected to ensure that it was representative of 95% of the recently drilled wells.

The 70 wells were reviewed to ensure accurate production data were available and to eliminate older wells that had been re-drilled into a new formation. Sixty-eight wells remained after the review. This was still a sufficient sample size to ensure statistical accuracy, so no additional wells were selected. The annual production values for oil, gas, and water; length of road constructed; well pad size; and travel distances to reach the well from the nearest town were calculated for each well. The lowest, highest, and mean values were then calculated for each parameter and used to create three emissions scenarios (maximum, minimum, and average). These values represent the maximum, minimum, and average emissions for 95% of the new wells in the CFO. Unforeseen or unpredictable events may cause 5% of wells to fall outside of the range. Because the minimum scenario has no production, it can be used to estimate the emissions from a saltwater disposal well.

Other values required for the calculator were conservatively estimated by BLM resource staff. It is not possible to predict the exact amount of time or equipment required for the development and operation of a well in the Permian Basin due to the varied geological formations, numerous operators, and other variables. Therefore, BLM specialists and engineers were consulted to develop a range of values to insert into the calculator to estimate the emissions from construction, completion, interim reclamation, annual operation, and final reclamation. The range was designed to include the requirements of 95% of the wells that may be developed in the Permian Basin. Where no information was available, the default values from the calculator were used. The calculator will be updated as additional information becomes available. The CFO is currently undertaking a plan revision and, as part of that, is revising its RFD and air modeling.

The ancillary activities associated with the production phase of a well such as workovers, road maintenance, and road traffic are difficult to predict. Oil and gas wells in the CFO do not require workover on a regular basis, and when these activities occur, they generally are not reported to the BLM; 3 to 6 years between workovers is routine, and the nature of the work required during a workover is variable. It is assumed that any gas released during the completion process will be flared.
The calculator assumes 100% combustion efficiency.

The emissions calculator can be used to estimate PM as a result of construction and drilling activities related to pad building and road traffic. The amount of PM emissions depends on the length, surface condition, soil types traversed, and soil moisture conditions of the road to the site. Because site visit frequencies vary and are difficult to predict, varying numbers of site visits were input into the calculator, which had almost no effect on the total tons of PM emitted. Most gas wells in the Permian Basin utilize remote telemetry powered by solar panels to transmit well production data to centralized office locations. The need for well site visits during the production phase at these wells is greatly reduced. Oil wells require site visits, and the frequency of well visits is not predictable.

While the frequency of well site visits is not predictable, the need for well site visits during the production phase of the well is greatly reduced by the telemetry systems. Typically, a field technician will drive a light truck and will visit multiple wells per trip along an established service route. It was estimated that an average trip distance consists of 2 miles three times per week. This information is used in calculating the annual operation emissions. Heavy trucks are required on-site less often than light trucks for various servicing needs. Heavy trucks typically do not visit multiple sites per day. Distances to the wells were determined from the statistical sample including the total distances traveled on dirt and paved roads to reach the well from the nearest town (Carlsbad, Artesia, Hobbs, etc.). Emissions include maintenance and inspection of the well. Reclamation of the well site and road will be conducted when the well has finished producing and is plugged and abandoned. Emissions from reclamation of the well pad and road are also estimated.

County roads in the CFO have established procedures for maintenance, but no regular maintenance schedule exists. Most new wells are drilled along oil and gas lease roads that are only maintained by oil and gas operators as needed. Therefore, road maintenance within the CFO is not predictable.
The average length of new road required to drill a new well during the past 4 years based on the random sample has been 570 feet. Emissions are calculated based on this average assuming that a 570-foot resource road is maintained once per year.

Maximum, minimum, and average emissions for construction, completion/recompletion, workover, annual operations, annual road maintenance, and reclamation have been calculated and are presented in project APD EAs. Note that these estimates are based on hypothetical scenarios and it is unlikely that the maximum emissions scenario would ever occur.

6.1.3 ASSUMPTIONS – OKLAHOMA FIELD OFFICE

Because development within the Oklahoma Field Office (OFO) can occur within a wide range of geographic areas and formations, a specific calculator has not been developed for this field office. However, calculators for other field offices may be used to obtain a reasonable estimate of emissions on a per-well basis. Updates to assumptions may be made where warranted if there is sufficient detail to determine with certainty better assumptions depending on the location of a project.

6.1.4 ADDITIONAL INFORMATION REGARDING CALCULATORS

The calculators in this document can be used to estimate emissions for all project types. Over time, calculators may be developed or modified to capture new or more regionally specific oil and gas development parameters (through ongoing modeling efforts associated with RMP revisions), or new project-specific calculators may emerge (such as those related to oil and gas leasing, e.g., the lease sale emissions tool). As new or more refined tools become available, they may be used to make emissions projections as warranted.

6.2 VOLATILE ORGANIC COMPOUNDS AND WELL DRILLING OPERATIONS

Specifically, VOCs are emitted during well drilling and operations as exhaust from internal combustion engines. VOCs may be emitted from hydraulically fractured oil and gas wells during fracturing and refracturing of the wells. In the hydraulic fracturing process, a mixture of water, chemicals, and proppant is pumped into a well at extremely high pressures to fracture rock and allow oil and gas to flow from the geological formation. During one stage of well completion, fracturing fluids, water, and reservoir gas come to the surface at high velocity and volume (flowback). This flowback mixture contains VOCs, methane (CH_4), benzene, ethylbenzene, and n-hexane; some or all of the flowback mixture may be vented, flared, or captured. The typical flowback process lasts from 3 to 10 days, so there is potential for significant VOC emissions from this stage of the well completion process. Most new oil and gas wells drilled today use the hydraulic fracturing process.

6.3 WELL COUNTS

The number of active wells can vary greatly from year to year; in addition, counts are not static or logarithmic by nature. Well count data can be obtained from many sources such as state oil and gas commission databases, university and research databases, and proprietary databases, as well as public federal databases. The sources reporting well counts may also differ in reporting methods. Reporting of well counts may include various types of wells such as active, new, temporarily abandoned, and inactive (shut in or temporarily abandoned). For the purposes of this report, the BLM uses the Petroleum Recovery Research Center, Automated Fluid Minerals Support System (AFMSS), and state oil and gas well count reporting.

According to data provided by the Petroleum Recovery Resource Center (PRRC), there are approximately 20,207 active wells within the San Juan Basin (McKinley, Rio Arriba, San Juan, and Sandoval Counties), of which approximately 14,302 are federal. Within the Permian Basin (Chaves, Eddy, Lea, and Roosevelt Counties), there are 41,006 active wells (primarily vertical wells), of which approximately 18,690 are federal (PRRC 2022).

7 AIR QUALITY RELATED VALUES

AQRVs are resources sensitive to air quality and can include a wide variety of atmospheric chemistry–related indicators. AQRVs include visibility and specific scenic, cultural, physical, biological, ecological, and recreational resources identified for a particular area. The NAAQS secondary standards are promulgated to ensure non-health related air quality impacts, such as AQRVs, are protected. The BLM can reasonably rely on compliance with the secondary NAAQS standard to prevent adverse impacts to these resources. Monitoring and modeling of AQRVs help to provide a level of protection to sensitive areas such as Class I parks and wilderness areas. Congress established certain national parks and wilderness areas as mandatory Class I areas where only a small amount of air quality degradation is allowed. Defined by the CAA, Class I areas include national parks greater than 6,000 acres, wilderness areas and national memorial parks greater than 5,000 acres, and international parks. These areas must have been in existence at the time the CAA was passed by Congress in August 1977.

The goal of Class I management is to protect natural conditions, rather than the conditions when first monitored. That is, if initial monitoring in a Class I area identifies human-caused changes, appropriate actions should be taken to remedy them to move toward a more natural condition. The goal of Class I management is to protect not only resources with immediate aesthetic appeal (i.e., sparkling clean streams) but also unseen ecological processes (such as natural biodiversity and gene pools) (U.S. Forest Service [USFS] et al. 2000). The Federal Land Managers' Air Quality Related Values Workgroup (FLAG) issued a revised Phase 1 report in 2010 (USFS et al. 2010). This report was developed as a tool to provide consistent approaches to the analysis of the effects of air pollution on AQRVs. The FLAG report focuses on three areas of potential impact: visibility, aquatic and terrestrial effects of wet and dry pollutant deposition, and terrestrial effects of O_3. This report is structured to address these same three areas of potential impact.

The BLM's goals include managing jurisdictional field office activities and development to protect and improve air quality and, within the scope of the BLM's authority, minimize emissions that cause or contribute to violations of air quality standards or that negatively impact AQRVs (e.g., acid deposition, visibility).

7.1 VISIBILITY

Visibility is of greatest concern in Class I areas, which are afforded the highest level of air quality protection by the CAA. Visibility impairment is a result of regional haze, which is caused by the accumulation of pollutants from multiple sources in a region. Emissions from industrial and natural sources may undergo chemical changes in the atmosphere to form particles of a size that scatter or absorb light and result in reductions in visibility.

The EPA and other agencies have been monitoring visibility in national parks and wilderness areas since 1988. In 1999, the EPA announced a major effort to improve air quality in national parks and wilderness areas. The Regional Haze Rule (40 C.F.R. 51, Subpart P, Protection of Visibility) calls for state and federal agencies to work together to improve visibility in 156 national parks and wilderness areas.

The rule requires the states, in coordination with the EPA, National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), USFS, and other interested parties, to develop and implement air quality protection plans to reduce the pollution that causes visibility impairment. The first state plans for regional haze were due in December 2007. States, tribes, and five multijurisdictional regional planning organizations worked together to develop the technical basis for these plans. Comprehensive periodic revisions to these initial plans were due July 31, 2021, and are due again in 2028, and every 10 years thereafter (EPA 2022n). Thirty-nine states failed to submit the 2021 regional haze plans to the EPA by the deadline of July 31, 2021. On April 7, 2022, the EPA announced its intent to issue findings for those states that failed to submit regional haze implementation plans for the second planning period. The EPA intends to issue these findings by August 31, 2022. States wishing to avoid inclusion in the Findings of Failure to Submit should submit their second planning period SIPs by August 15, 2022. States implement the Regional Haze Program through SIPs in accordance with the federal Regional Haze Rule and are discussed in more detail in Section 12.

In 1985, the EPA initiated a network of monitoring stations to measure impacts to visibility in Class I Wilderness Areas. These monitors are known as the Interagency Monitoring for the Protection of Visual Environments (IMPROVE) monitors and exist in some, but not all, Class I wilderness areas. Table 9 shows the Class I areas in the BLM NMSO jurisdiction and whether they have an IMPROVE monitor and, if not, which monitor is considered representative for that area. There are no Class I areas in Kansas.

Table 9. Class I Areas and IMPROVE Monitors

State	Class I Area	Agency	IMPROVE
New Mexico	Bandelier	NPS	Yes
	Bosque del Apache	USFWS	Yes
	Carlsbad Caverns	NPS	Guadalupe Mountains
	Gila	USFS	Yes
	Pecos	USFS	Wheeler Peak
	Salt Creek	USFWS	Yes
	San Pedro Parks	USFS	Yes
	Wheeler Peak	USFS	Yes
	White Mountain	USFS	Yes
Texas	Big Bend	NPS	Yes
	Guadalupe Mountains	NPS	Yes
Oklahoma	Wichita Mountains	USFWS	Yes

Figure 8 through Figure 10 shows visibility extinction trends for each of the IMPROVE monitors in the BLM NMSO area of responsibility. Note that peaks such as those seen for Bandelier National Monument in 2000 may be accounted for by the occurrence of large wildfires. A downward sloping line means less reduction of visibility and therefore an improvement. In most cases, visibility trends have been flat or improving. Implementation of best available retrofit technology (BART) strategies as required under the federal Regional Haze Rule over the next few years should result in further improvements.

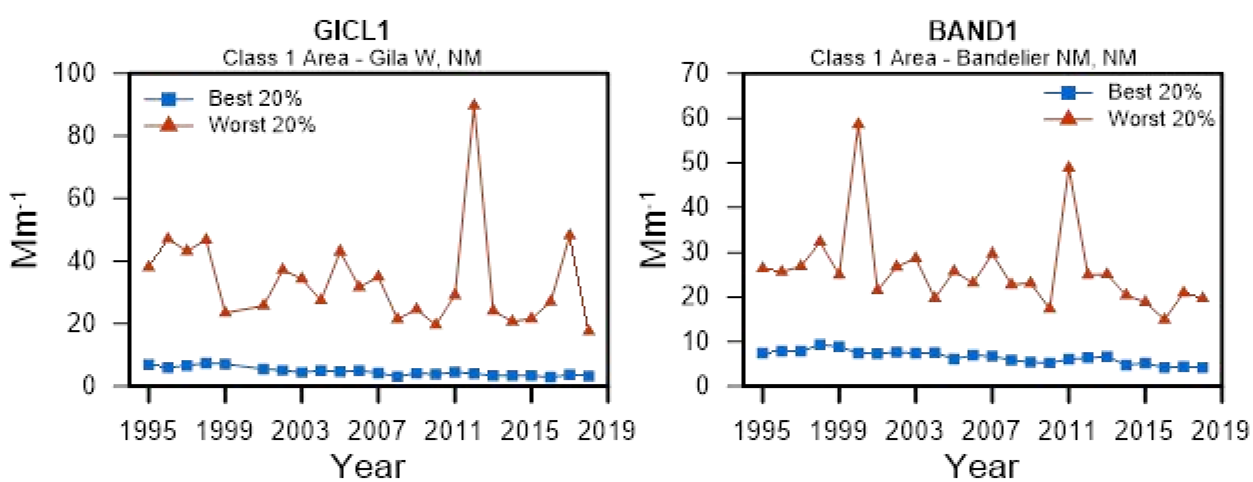


Figure 8. Visibility extinction trends for the Gila Wilderness Area and Bandelier National Monument, New Mexico (data retrieved from Colorado State University [2020]).

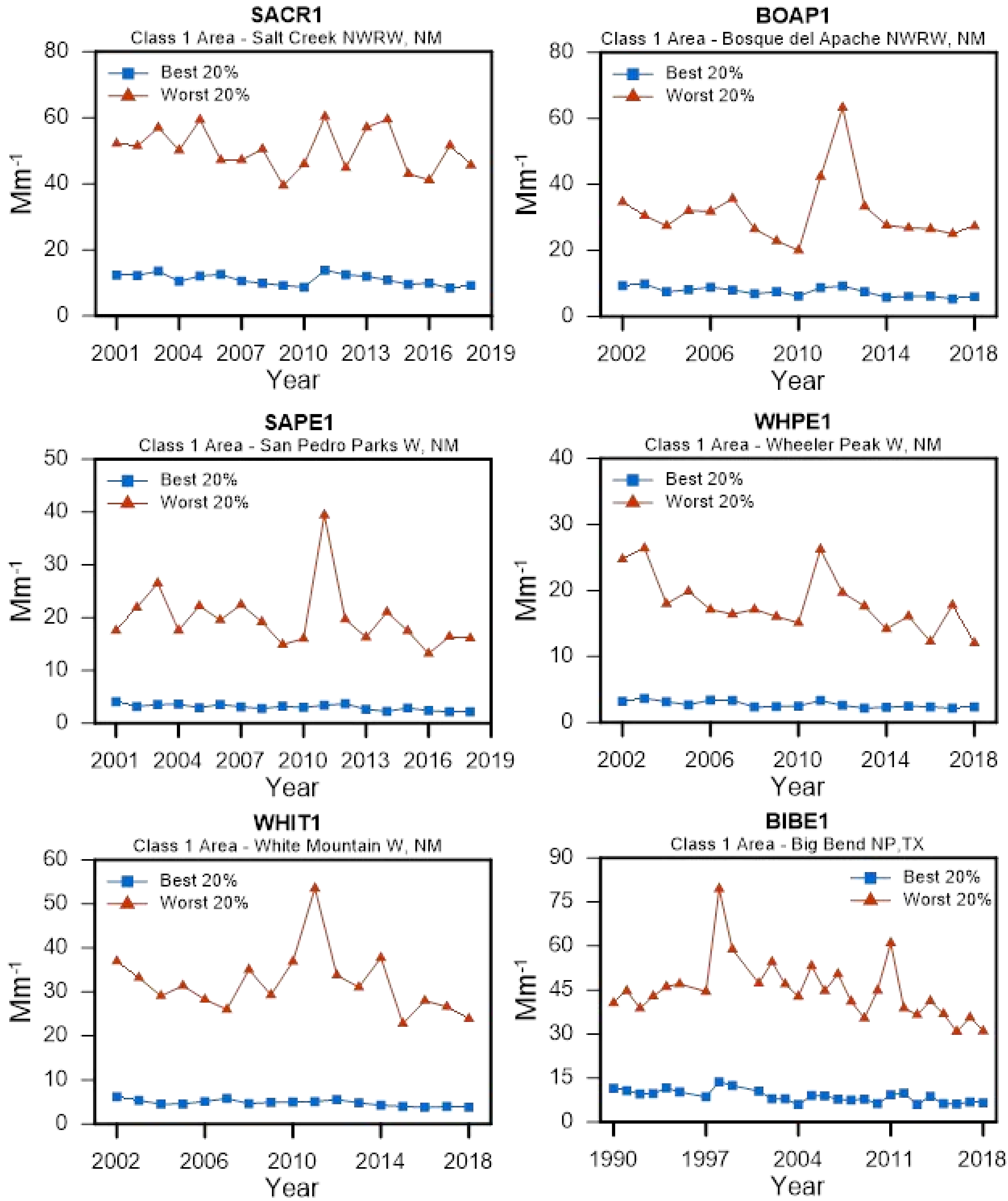


Figure 9. Visibility extinction trends for six Class I areas (data retrieved from Colorado State University [2020]).

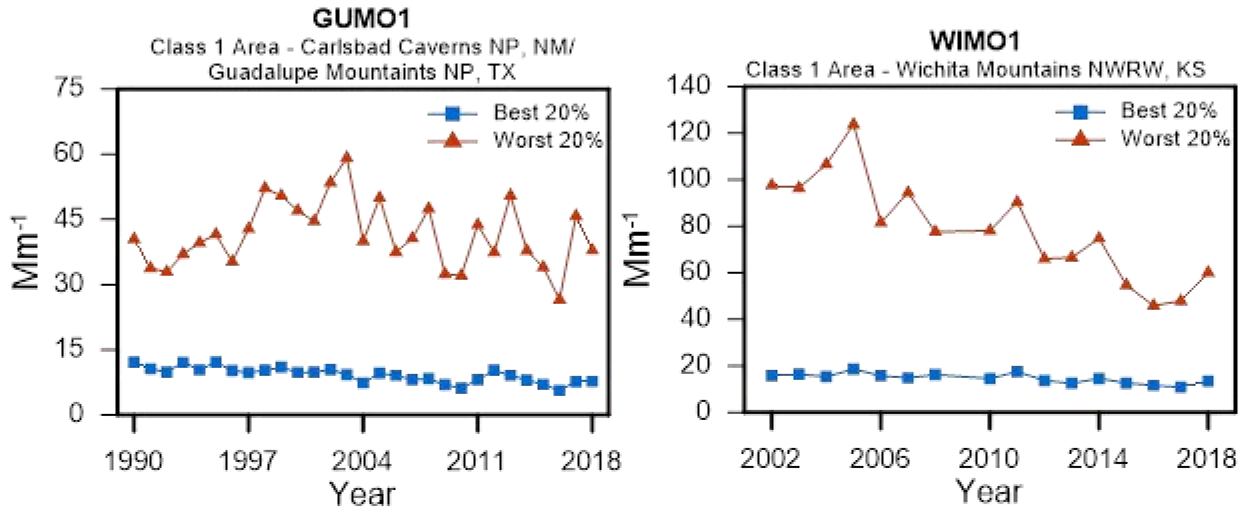


Figure 10. Visibility extinction trends for the Carlsbad Caverns National Park and Wichita Mountains National Wildlife Refuge (data retrieved from Colorado State University [2020]).

Trend lines for Class I areas affected by sources in northwestern New Mexico (Figure 11) are similar to trend lines for Class I areas in New Mexico. While visibility on worst days at Guadalupe Mountains National Park may have diminished, a careful analysis of fire activity in the area would be necessary in order to draw conclusions about the cause of some peaks in recent years (Colorado State University 2020).

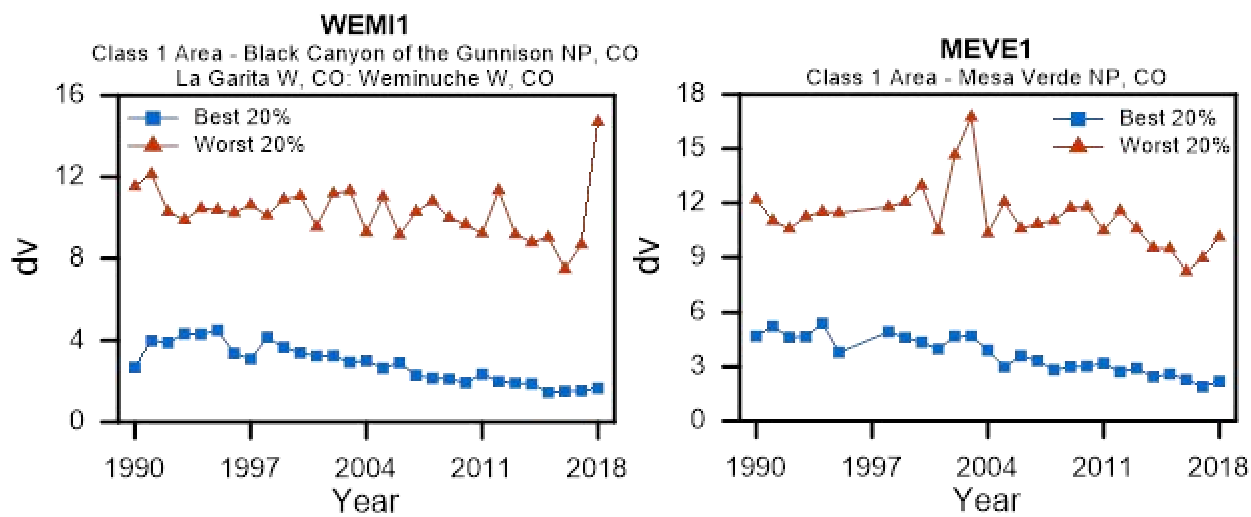


Figure 11. Visibility trends at Class I areas affected by sources in northwestern New Mexico (data retrieved from Colorado State University [2020])

A qualitative discussion of visibility impacts from oil and gas development in the Farmington RMP concludes that for the scenario modeled, which projected greater development than has occurred, there could potentially be significant impacts to visibility at Mesa Verde National Park, a Class I area in southwestern Colorado. Occasional impacts to San Pedro Parks (northern New Mexico) and Weminuche (southern Colorado) Wilderness Areas were also thought possible. However, visibility trends shown below for San Pedro Parks, Mesa Verde, and Weminuche indicate that visibility on the best days has been flat to improving and visibility on worst days has shown little change over the period of record.

Visibility modeling was performed using the BLM CFO RFD potential oil and gas well development scenario and with mitigation using EPA's on-the-books emission controls and additional management controls. This analysis tiers to the modeling that was performed in the ARTSD (URS 2013) for the BLM CFO for results of visibility impairment, indicating that, for the Carlsbad region, visibility effects on Carlsbad Caverns National Park (CCNP) at the project level are minimal and not expected to be of concern (Engler et al. 2012; Engler and Cather 2014; URS 2013). The visibility screening analysis followed the recommendations in the FLAG Phase I Report – Revised Guidelines (USFS et al. 2010). The analysis relies on a 0.5 and 1.0 delta-deciview (change in visibility) threshold, calculated for base year 2008, base case 2017, and future RFD years. Non-project, aggregate emissions are driving the overall visibility effects. A refinement of the aggregate emissions would reduce the number of days of total visibility effects and would likely be closer to baseline and future visibility effects. Any refinement down to a smaller scope of development or project-specific level would likely reduce the number of days of total visibility effects that would be likely, closer to matching actual base and future visibility effects/baseline conditions (URS 2013). Further refinement of the URS 2013 visibility modeled results was performed to show relative effects. The results indicate that there are no days in which the threshold is exceeded at the project level for the CCNP. An additional study of air pollutant emissions and cumulative air impacts done for the CFO indicates that pollutants contributing to reductions in visibility are largely coming from outside the region (Applied EnviroSolutions 2011).

7.2 WET AND DRY POLLUTANT DEPOSITION

Deposition of pollutants through precipitation can result in acidification of water and soil resources in areas far removed from the source of the pollution, as well as causing harm to terrestrial and aquatic species. Some pollutants can also damage vegetation through direct or dry deposition. In general, the soils in New Mexico have a high acid neutralizing capacity and surface water is scarce, resulting in minimal impacts in this area. Also, the Acid Rain Program has resulted in greatly reduced levels of the most damaging pollutants. There are currently two active wet deposition monitors in New Mexico: Mayhill and Bandelier National Monument. In addition, monitors near the border at Mesa Verde and Guadalupe Mountains National Parks may shed some light on conditions in New Mexico. Data can be accessed through the National Atmospheric Deposition Program (NADP) at https://nadp.slh.wisc.edu/networks/national-trends-network/. Wet deposition data are also available for monitoring sites in Kansas, Oklahoma, and Texas at this site.

The EPA has operated the Clean Air Status and Trends Network (CASTNET) since 1991 to provide data to assess trends in air quality, deposition, and ecological effects due to changes in air emissions. Sites are located in areas where urban influences are minimal. There are currently two CASTNET observation sites in New Mexico, three in Texas, two in Kansas and one in Oklahoma. There is also a CASTNET site at Mesa Verde National Park in the Four Corners region. National maps of pollutant concentrations can be found at https://www3.epa.gov/castnet/airconc.html. These maps show that New Mexico and most of the western states have much lower concentrations of all monitored pollutants than the eastern states and southern California. Nitrates are somewhat elevated in eastern Kansas and eastern Oklahoma, but this is likely associated with agricultural activities rather than oil and gas development. The maps also show that the trend over the past 30 years has been for decreases in all pollutants in most areas of the country. As an example, Figure 12 and Figure 13 show particulate nitrate and sulfate levels for 1990 and 2019. Maps of wet deposition data from NADP monitors are also available from the NADP (2019). Total nitrogen deposition decreased by 51% from 1990 through 2016 in the eastern United States and decreased by 27% in the western United States between 1996 through 2014; however, total nitrate concentrations measured at the eastern sites were generally two to three times higher than concentrations measured at western reference sites. Total dry and wet sulfur deposition decreased by 89% from 1990 through 2016 in the eastern United States and decreased by 45% from 1996 through 2016 in the west, over 3-year mean periods. Figure 12 through Figure 17 show the total nitrate and total dry and wet sulfur deposition trends through 2019. These trends in deposition levels are discussed in depth in the CASTNET annual report (EPA 2022s).

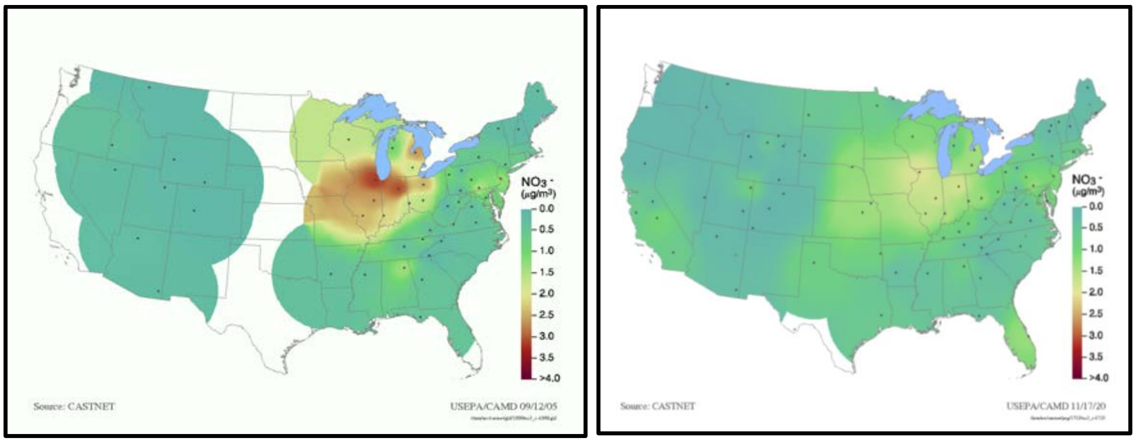


Figure 12. Particulate nitrate in 1990 (left) and 2019 (right).

Source: EPA (2019)

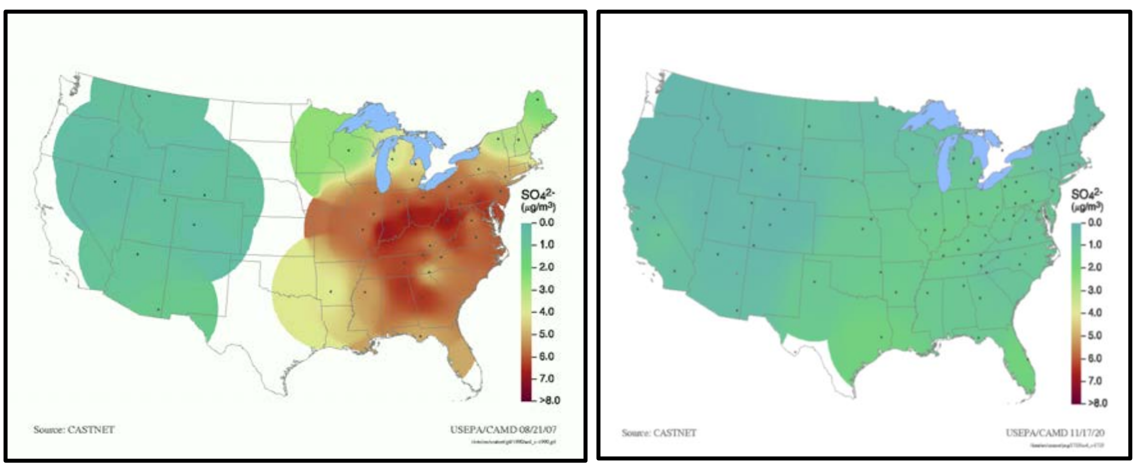


Figure 13. Particulate sulfate in 1990 (left) and 2019 (right).

Source: EPA (2019).

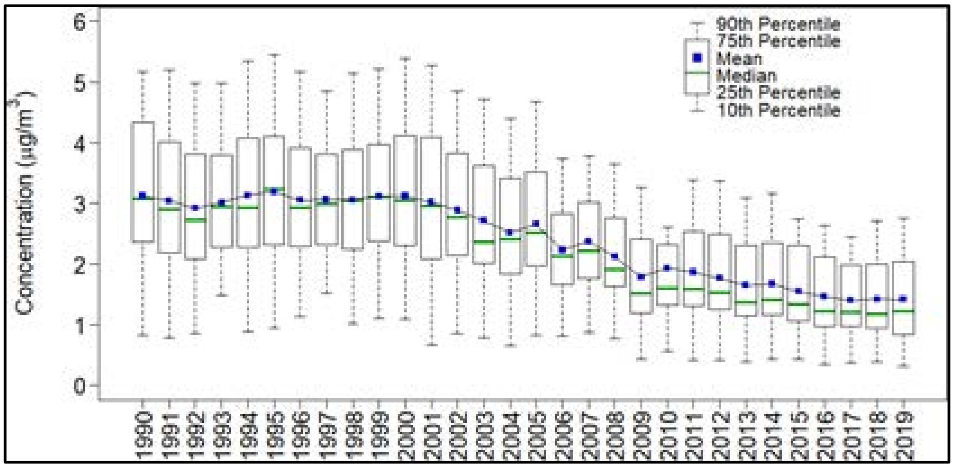


Figure 14. Trends in annual mean total nitrate concentrations – eastern reference sites.

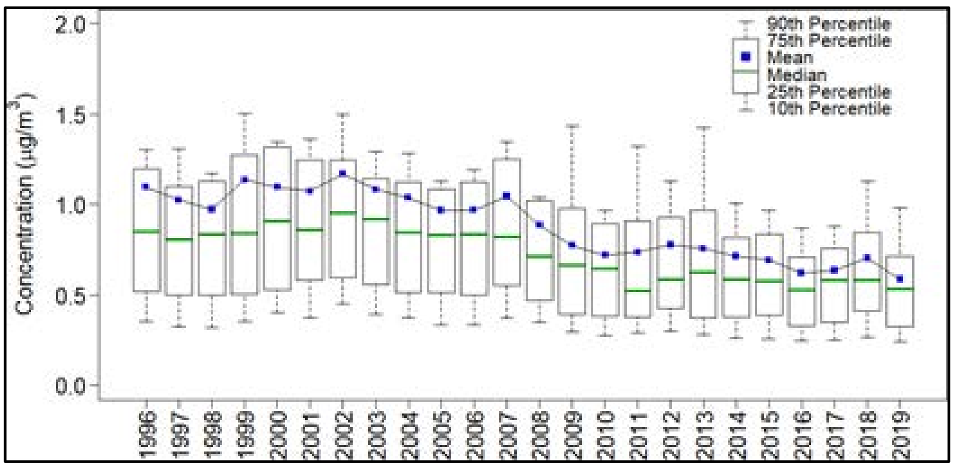


Figure 15. Trends in annual mean total nitrate concentrations – western reference sites.

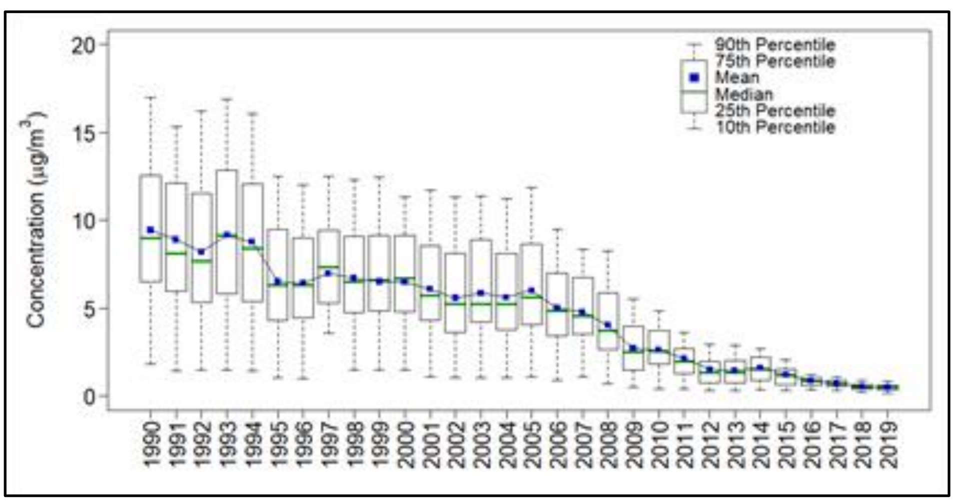


Figure 16. Trends in annual mean SO_2 concentrations – eastern reference sites.

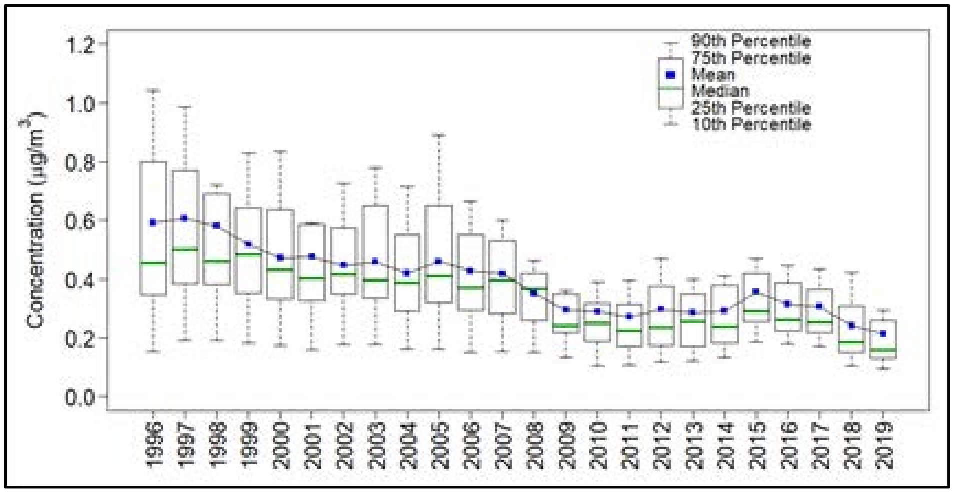


Figure 17. Trends in annual mean SO_2 concentrations – western reference sites.

Tables showing the species contributing to nitrogen and sulfur deposition at Class I areas in New Mexico, Texas, Oklahoma, and Kansas are in Appendix E.

7.3 VISIBILITY AND DEPOSITION MODELING

Visibility—Visibility modeling was performed using the CFO RFD potential oil and gas well development scenario and with mitigation using EPA's on-the-books emission controls and additional management controls. This analysis tiers to the modeling that was performed in the ARTSD for the CFO for results of visibility impairment indicating that, for the Carlsbad region, visibility impacts to CCNP at the project level are minimal and not expected to be of concern for the CCNP (Engler et al. 2012; URS 2013).
The visibility screening analysis followed the recommendations in the FLAG Phase I Report – Revised Guidelines (USFS et al. 2010). The analysis relies on a 0.5 and 1.0 delta-deciview (change in visibility) threshold, calculated for base year 2008, base case 2017, and future RFD years. Non-project, cumulative emissions are driving the overall visibility impacts. A refinement of the cumulative emissions would reduce the number of days of total visibility impacts and would likely be closer to baseline and future visibility impacts. Any refinement down to a smaller scope of development or project-specific level would likely reduce the number of days of total visibility impacts that would be likely closer to matching actual base and future visibility impacts/baseline conditions (URS 2013). The URS 2013 visibility modeled results were further refined to show relative impacts. The results indicate that there are no days in which the threshold is exceeded at the project level for the CCNP.

Deposition—Deposition modeling was performed using the CFO RFD potential oil and gas well development scenario and with mitigation using EPA's on-the-books emission controls and additional management controls. This analysis tiers to the modeling that was performed in the ARTSD for results of nitrogen and sulfur deposition impairment (Engler et al. 2012; URS 2013).

To assess potential nitrogen and sulfur deposition impacts in the planning area, deposition impacts were compared with the NPS screening deposition analysis thresholds (DATs), which are defined as 0.005 kilogram per hectare per year (kg/ha/yr) in the western United States for both nitrogen and sulfur. A DAT is the additional amount of nitrogen or sulfur deposition within a Class I area, below which estimated impacts from a proposed new or modified source are considered to be insignificant. The DAT is a screening threshold that was developed primarily to assess impacts from a single stationary source

(USFS et al. 2000, 2010). Modeling results showing deposition greater than a DAT do not strictly indicate the need for mitigation. If a DAT is exceeded, cumulative modeling may be required to demonstrate that cumulative deposition is below the level of concern (LOC). The LOC for the nitrogen and sulfur deposition values, defined by the NPS and USFS, is 3 kg/ha/yr for nitrogen and 5 kg/ha/yr for sulfur (Fox et al. 1989).

Results of analysis showed that the maximum annual nitrogen DAT at the project level was exceeded for CCNP but may be below the LOC at specific receptors. The CFO RFD modeling results showed that the predicted nitrogen deposition was expected to be below the LOC value of 3 kg/ha/yr for CCNP (Table 10) (URS 2013). The maximum annual sulfur DAT at the project level (CFO RFD) was below the DAT and LOC threshold for CCNP. Deposition rates that are below the LOC are believed to cause no adverse impacts. Appendix R and Appendix S of the ARTSD provide detailed nitrogen deposition results for project level and cumulative impacts, respectively (URS 2013).

Table 10. Maximum Annual Nitrogen Deposition

Area with Greatest Predicted Impact	Maximum Modeled Project Deposition (kg/ha/yr)	DAT* (kg/ha/yr)	Background Deposition (kg/ha/yr)	Total Project Deposition (kg/ha/yr)	LOC† (kg/ha/yr %)
Class I		0.005			
Salt Creek Wilderness	0.29	5,800%	2.59	2.88	93%
Carlsbad Caverns National Park	0.19	3,800%	2.59	2.77	92%
Sensitive Class II		0.005			3.0
Bitter Lake National Wildlife Refuge	0.29	5,800%	2.59	2.88	93%
Grulla National Wildlife Refuge	0.11	2,200%	2.59	2.70	90%

Source: URS (2013)

* The DAT is shown in italics, while the maximum modeled deposition is provided as a percentage of the DAT.

† The LOC is shown in italics, while the maximum total deposition is shown as a percentage of the LOC.

To assess potential cumulative effects to AQRVs, the air quality assessment considers emissions and potential impacts of expected growth oil and gas development for nearby oil and gas basins, as well as the Permian Basin, including the Raton Basin, San Juan Basin, Denver-Julesburg Basin, White River Field Office, Colorado River Valley Field Office, Utah Vernal Field Office, and Oklahoma, Kansas, and Texas Oil and Gas Basins (URS 2013). Cumulative scenario results were above the nitrogen and sulfur LOC for CCNP. It should be noted that for a large aggregate project that includes thousands of sources (such as oil and gas development in the BLM CFO) and deposition greater than the DAT, as well as LOC, is typical based on the uncertainty in the model parameters, and more refined modeling studies are often required to better understand potential effects. Future potential development in the region as a whole could result in degradation of air quality related to nitrogen deposition, depending on the number of sources present during development and any mitigation applied. Appropriate mitigation would be determined following further analysis at the site-specific APD stage of a project that allows for refined modeling analysis (as appropriate), which incorporates project-specific information.

In 2016, Chevron developed a Master Development Plan in which 436 oil and gas wells were projected to be developed across 106 well pads. Although it is not anticipated that all wells will be developed concurrently during this project, similar results of AQRVs can be expected for large well development projects. The Chevron analysis extends the URS (2013) modeling that was performed and updates NO_x emissions in the project area. The results of acid deposition monitoring showed incremental exceedances of the nitrogen DAT of 0.005 kg/ha/yr in the CCNP during drilling operations but would be well below the DAT once drilling is completed (BLM 2016).

It is expected that a refined analysis may be required at the time of proposed lease development for well development that could potentially impact nitrogen deposition at the CCNP. A refined analysis of acid deposition must address 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?

This refined analysis should be in consultation with the NPS as prescribed in FLAG guidance (USFS et al. 2011). Federal land managers will do their best to manage and protect resources at every area that they administer. Federal land managers believe that the need to minimize potential impacts to a Class I area should be a major consideration in the best available control technology determination for a project proposed near such an area. Therefore, if a source proposes to locate near a Class I area, additional costs to minimize impacts to sensitive Class I resources may be warranted, even though such costs may be considered economically unjustified under other circumstances (USFS et al. 2010).

8 CUMULATIVE EFFECTS

More specific information about sources in New Mexico's oil and gas producing regions that have the greatest impacts on air quality and GHGs is included below. The Council on Environmental Quality (CEQ) regulations define cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such actions" (40 C.F.R. 1508.7).

8.1 CURRENT AND REASONABLY FORESEEABLE CONTRIBUTIONS TO CUMULATIVE EFFECTS

A list of major sources (sources emitting more than 100 tpy of CO, VOC, NO_x, SO_2, $PM_{2.5}$, or PM_{10}) in New Mexico, Kansas, Oklahoma, and Texas can be found in Appendix D. Any of these sources may contribute to cumulative effects within a local or regional context. All major sources represent emissions from the NEI report (EPA 2020b).

9 CLIMATE, CLIMATE CHANGE, AND GREENHOUSE GASES

9.1 CLIMATE

Climate is the composite of generally prevailing weather conditions of a particular region throughout the year, averaged over a series of years. Climate averages for 1991 to 2020, known as the current normal as defined by the World Meteorological Organization, are 30-year averages of temperature and precipitation for the previous three decades and are included in Appendix C.

9.2 CLIMATE CHANGE

Climate change is a statistically significant and long-term change in climate patterns. The terms climate change and global warming, though often used interchangeably, are not the same. Climate change is any deviation from the average climate via warming or cooling and can result from both natural and human (anthropogenic) sources. Natural contributors to climate change include fluctuations in solar radiation, volcanic eruptions, and plate tectonics. Global warming refers to the apparent warming of climate observed since the early twentieth century and is primarily attributed to human activities such as fossil fuel combustion, industrial processes, and land use changes.

Climate change may reinforce (positive feedback) or reduce (negative feedback) an expected temperatures increase. A feedback is the process by which changing one quantity results in the amplification or diminishment of another. An example of a positive feedback is the reduced albedo (reflectivity) of land surfaces from the melting of snow and ice. A warming climate is also expected to increase CH_4 release from hydrates, thereby reinforcing the warming trend. There are also feedbacks related to carbon, water, and geochemical cycles. The results of most climate feedbacks are expected to amplify warming, but the exact magnitudes of these effects are difficult to quantify (Intergovernmental Panel on Climate Change [IPCC] 2013).

9.3 GREENHOUSE GASES

Atmospheric concentrations of naturally emitted GHGs have varied for millennia, and Earth's climate fluctuated accordingly. However, since the beginning of the industrial revolution around 1750, human activities have significantly increased GHG concentrations and introduced man-made compounds that act as GHGs in the atmosphere. The atmospheric concentrations of CO_2, CH_4, and nitrous oxide (N_2O) have increased to levels unprecedented in at least the last 800,000 years. From pre-industrial times until today, the global average concentrations of CO_2, CH_4, and N_2O in the atmosphere have increased by around 50%, 163%, and 24%, respectively. Table 11 shows the average global concentrations of CO_2, CH_4, and N_2O in 1750, 2011, and 2021. Atmospheric concentrations of GHGs are reported in parts per million (ppm) and parts per billion (ppb).

Table 11. Average Global Concentrations of GHGs in Select Years

Greenhouse Gas	Pre-Industrial 1750	2011	2021	Increase 1750–2021
Carbon dioxide (CO_2)	278 ppm	390.5 ppm	416 ppm[(1)]	50%
Methane (CH_4)	722 ppb	1,803 ppb	1,896 ppb[(2)]	163%

Greenhouse Gas	Pre-Industrial 1750	2011	2021	Increase 1750–2021
Nitrous oxide (N_2O)	270 ppb	324 ppb	334 ppb(2)	24%

(1) The atmospheric CO_2 concentration is the 2021 annual average at the Mauna Loa, Hawaii, station (National Oceanic Atmospheric Administration [NOAA] 2021). The global atmospheric CO_2 concentration, computed using an average of sampling sites across the world, was 415 ppm in 2021 (NOAA 2021).

(2) The values presented are global 2021 annual average mole fractions (NOAA 2021).

Human activities emit billions of tons of CO_2 every year. CO_2 is primarily emitted from fossil-fuel combustion but has a variety of other industrial sources. CH_4 is emitted from oil and natural gas systems, landfills, mining, agricultural activities, waste, and other industrial processes. N_2O is emitted from anthropogenic activities in the agricultural, energy-related, waste, and industrial sectors.
The manufacture of refrigerants and semiconductors, electrical transmission, and metal production emit a variety of trace GHGs (including hydrofluorocarbons [HFCs], perfluorocarbons [PFCs], and sulfur hexafluoride [SF_6]). These trace gases have no natural sources and come entirely from human activities. CO_2, CH_4, N_2O, and the trace gases are considered well-mixed and long-lived GHGs. The atmospheric lifespan for CO_2 can vary but is on the order of hundreds of years. The atmospheric lifespan of CH_4 and N_2O are 12.4 years and 121 years, respectively (IPCC 2013).

9.4 OTHER GASES, ATMOSPHERIC AEROSOLS, AND PARTICULATES

Several gases do not have a direct effect on climate change, but indirectly affect the absorption of radiation by impacting the formation or destruction of GHGs. These gases include CO, NO_X, and non-CH_4 VOCs. Fossil fuel combustion and industrial processes account for the majority of emissions of these indirect GHGs. Unlike other GHGs, these gases are short-lived in the atmosphere.

Atmospheric aerosols, or particulate matter (PM), also contribute to climate change. Aerosols directly affect climate by scattering and absorbing radiation (aerosol-radiation interactions) and indirectly affect climate by altering cloud properties (aerosol-cloud interactions). Particles less than 10 micrometers in diameter (PM_{10}) typically originate from natural sources and settle out of the atmosphere in hours or days. Particles smaller than 2.5 micrometers in diameter ($PM_{2.5}$) often originate from human activities such as fossil fuel combustion. These so-called “fine” particles can exist in the atmosphere for several weeks and have local short-term impacts on climate. Aerosols can also act as cloud condensation nuclei, the particles upon which cloud droplets form.

Light-colored particles, such as sulfate aerosols, reflect and scatter incoming solar radiation, having a mild cooling effect, while dark-colored particles (often referred to as “soot” or “black carbon”) absorb radiation and have a warming effect. There is also the potential for black carbon to deposit on snow and ice, altering the surface albedo (or reflectivity), and enhancing melting. There is high confidence that aerosol effects are partially offsetting the warming effects of GHGs, but the magnitude of their effects contribute the largest uncertainty to our understanding of climate (IPCC 2013).

9.5 THE NATURAL GREENHOUSE EFFECT

The natural greenhouse effect is critical to the discussion of climate change. The greenhouse effect refers to the process by which GHGs in the atmosphere absorb heat energy radiated by Earth’s surface.

Water vapor is the most abundant GHG, followed by CO_2, CH_4, N_2O, and several trace gases. Each of these GHGs exhibit a particular "heat trapping" effect, which causes additional heat retention in the atmosphere that would otherwise be radiated into space. The greenhouse effect is responsible for Earth's warm atmosphere and temperatures suitable for life on Earth. Different GHGs can have different effects on the Earth's warming due to their ability to absorb energy ("radiative efficiency") and how long they stay in the atmosphere ("lifetime"). Without the natural greenhouse effect, the average surface temperature of the Earth would be about zero degrees Fahrenheit (°F). Water vapor is often excluded from the discussion of GHGs and climate change since its atmospheric concentration is largely dependent upon temperature rather than being emitted by specific sources.

9.6 GREENHOUSE GASES AND GLOBAL WARMING POTENTIALS

Common air emissions related to oil and gas activities include CO_2, CH_4, and N_2O. Other industries emit more potent GHGs, including several fluorinated species of gases such as HFCs, PFCs, and SF_6. CO_2 is emitted from the combustion of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and as a result of other chemical reactions (e.g., manufacture of cement). The production and transport of coal, natural gas, and oil emit CH_4, which can also be emitted from coal mining operations, naturally occurring coal CH_4 seepages, releases/leaks from the oil and gas industry, livestock, and other agricultural practices and by the decay of organic waste in municipal solid waste landfills. Agricultural and industrial activities emit N_2O, as well as combustion of fossil fuels and solid waste. Fluorinated gases are powerful GHGs that are emitted from a variety of industrial processes and are often used as substitutes for O_3-depleting substances (i.e., CFCs, hydrochlorofluorocarbons [HCFCs], and halons), but typically not from oil and gas operations. SF_6 is the most potent (highest radiative efficiency) GHG known and is typically used as an insulator in circuit breakers, gas-insulated substations, and switchgear used in the transmission system to manage the high voltages carried between power generating stations and customer load centers.

All of the different GHGs have various capacities to trap heat in the atmosphere, known as global warming potentials (GWPs). GWP is a relative measure that compares the heat absorbing ability of a certain mass of a gas relative to the same mass of CO_2 (EPA 2022o) A second metric that is gaining prominence is global temperature change potential, which is based on the change in global mean surface temperature at a chosen point in time, relative to that caused by CO_2. A number of other metrics may also be used, but no single metric accurately compares all consequences, and the choice of metric is a value judgment (IPCC 2013).

Several different time horizons can express GWPs to fully account for the gases' ability to absorb infrared radiation (heat) over their atmospheric lifetime. The BLM uses the 100-year time horizon since most of the climate change impacts derived from climate models are expressed toward the end of the century. Also, in accordance with international GHG reporting standards under the United Nations Framework Convention on Climate Change and in order to maintain consistent comparisons over the years, official GHG emission estimates for the United States are reported based on the GWP values given in the Fourth Assessment Report (AR4) of the IPCC (IPCC 2007).

Updated GWPs were reported in the Fifth Assessment Report (AR5) as the level of scientific understanding increased. The IPCC is currently in its sixth assessment cycle, during which the IPCC will produce the assessment reports of its three working groups, three special reports, a refinement to the methodology report, and the synthesis report. The synthesis report will be the last of the AR6 products, due for release in late 2022 or early 2023. The Sixth Assessment Report (AR6) GWP values will account for changes in radiative properties, atmospheric lifetimes, and indirect contributions of the different gases. The atmospheric lifetimes and GWPs for the major GHGs over the 20-year and 100-year time horizons are listed below in Table 12. CO_2 has a GWP of 1, and for the purposes of analysis a GHG's GWP is generally standardized to a carbon dioxide equivalent (CO_2e), or the equivalent amount of CO_2 mass the GHG would represent. In the AR5 report, CH_4 has a GWP estimated to be 28 and N_2O has a GWP of 265 (IPCC 2013). Table 11 also shows the preliminary AR6 report GWP values, CH_4 has been broken down into fossil and non-fossil origin and N_2O has a GWP of 273 (IPCC 2021).

Table 12. Global Warming Potentials (100-year time horizon)

Greenhouse Gas	GWP Values for 100-year Time Horizon		
	AR4[1]	**AR5**	**AR6**
Carbon dioxide (CO_2)	1	1	1
Methane (CH_4)	25	28	Fossil origin – 29.8 Non-fossil origin – 27.2
Nitrous oxide (N_2O)	298	265	273
Select hydrofluorocarbons (HFCs)	124–14,800	4–12,400	-
Sulfur hexafluoride (SF_6)	22,800	23,500	-
Greenhouse Gas	**GWP Values for 20-year Time Horizon**		
	AR4	**AR5**	**AR6**
Carbon dioxide (CO_2)	1	1	1
Methane (CH_4)	72	84	Fossil origin – 82.5 Non-fossil origin – 80.8
Nitrous oxide (N_2O)	299	264	273
Select hydrofluorocarbons (HFCs)	437–12,000	<1–10,800	-
Sulfur hexafluoride (SF_6)	16,300	17,500	-

Sources: IPCC (2007, 2013)

(1) For consistency with the EPA and its Inventory of Greenhouse Gas Reporting, we have represented values from AR4 of the IPCC report in this report.

9.7 CLIMATE CHANGE PROJECTIONS

Our current understanding of the climate system comes from the cumulative results of observations, experimental research, theoretical studies, and model simulations. Climate change projections are based on a hierarchy of climate models that range from simple to complex, coupled with comprehensive Earth System Models. For AR5, scientists estimated future climate impacts based on a range of Representative Concentration Pathways (RCPs) for well-mixed GHGs in model simulations carried out under the Coupled Model Intercomparison Project Phase 5 of the World Climate Research Programme (IPCC 2013). The RCPs represent a range of mitigation scenarios that are dependent on socioeconomic and geopolitical factors and have different targets for radiative forcing in 2100 (2.6, 4.5, 6.0, and 8.5 W m^{-2}). The scenarios are illustrative and do not have probabilities assigned to them.

AR5 uses terms to indicate the assessed likelihood of an outcome ranging from exceptionally unlikely (0%–1% probability) to virtually certain (99%–100% probability) and level of confidence ranging from very low to very high. The findings presented in AR5 indicate that warming of the climate system is unequivocal and many of the observed changes are unprecedented over decades to millennia. It is certain that global mean surface temperature has increased since the late nineteenth century and virtually certain (99%–100% probability) that maximum and minimum temperatures over land have increased on a global scale since 1950. The globally averaged combined land and ocean surface temperature data show a warming of 0.85 degree Celsius (°C) (1.5°F) (IPCC 2013; National Oceanic and Atmospheric Administration [NOAA] 2013). Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. It is extremely likely (95%–100% probability) that human influence has been the dominant cause of the observed warming since the mid-twentieth century (IPCC 2013).

Additional near-term warming is inevitable due to the thermal inertia of the oceans and ongoing GHG emissions. Assuming there are no major volcanic eruptions or long-term changes in solar irradiance, global mean surface temperature increase, for the period 2016 to 2035 relative to 1986 to 2005, will likely be in the range of 0.3°C to 0.7°C (0.5°F–1.3°F). Global mean temperatures are expected to continue rising over the twenty-first century under all of the projected future RCP concentration scenarios. Global mean temperatures in 2081 to 2100 are projected to be between 0.3°C to 4.8°C (0.5°F–8.6°F) higher relative to 1986 to 2005 (IPCC 2013). The IPCC projections are consistent with reports from other organizations (National Atmospheric Science Administration [NASA] 2013; Joint Science Academies 2005).

Findings from AR5 and reported by other organizations (NASA 2013; NOAA 2013) also indicate that changes in the climate system are not uniform and regional differences are apparent. Some regions will experience precipitation increases, and other regions will have decreases or not much change.
The contrast in precipitation between wet and dry regions and between wet and dry seasons is expected to increase. The high latitudes are likely (66%–100% probability) to experience greater amounts of precipitation due to the additional water carrying capacity of the warmer troposphere. Many mid-latitude arid and semi-arid regions will likely (66%–100% probability) experience less precipitation (IPCC 2013).

9.7.1 GENERAL CLIMATE CHANGE PREDICTIONS

Climate change is a global process that is impacted by the sum total of GHGs in the Earth's atmosphere. Currently, global climate models are unable to forecast local or regional effects on resources (IPCC 2013). However, there are general projections regarding potential impacts to natural resources and plant and animal species that may be attributed to climate change from GHG emissions over time; however, these effects are likely to be varied, including those in the southwestern United States (Karl 2009). For example, if global climate change results in a warmer and drier climate, increased particulate matter impacts could occur due to increased windblown dust from drier and less stable soils. Cool season plant species' spatial ranges are predicted to move north and to higher elevations, and extinction of endemic threatened or endangered plants may be accelerated. Due to loss of habitat or competition from other species whose ranges may shift northward, the populations of some animal species may be reduced or increased. Less snow at lower elevations would likely impact the timing and quantity of snowmelt, which, in turn, could impact water resources and species dependent on historic water conditions (Karl 2009).

Climate change will impact regions differently, and warming will not be equally distributed. Both observations and computer model predictions indicate that increases in temperature are likely to be greater at higher latitudes, where the temperature increase may be more than double the global average. Warming of surface air temperature over land will very likely be greater than over oceans (IPCC 2013). There is also high confidence that warming relative to the reference period will be larger in the tropics and subtropics than in mid-latitudes. Frequency of warm days and nights will increase and frequency of cold days and cold nights will decrease in most regions. 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. Models also predict increases in duration, intensity, and extent of extreme weather events. The frequency of both high- and low-temperature events is expected to increase. Near- and long-term changes are also projected in precipitation, atmospheric circulation, air quality, ocean temperatures and salinity, and sea ice cover.

9.7.2 REGIONAL CLIMATE CHANGE PREDICTIONS

In the region encompassing southern Colorado and New Mexico, average temperatures rose just under 0.7°F per decade between 1971 and 2011, which is approximately double the global rate of temperature increase (Rahmstorf 2012). These rates of warming are unprecedented over the past 11,300 years (Marcott 2013). Climate modeling suggests that average temperatures in the New Mexico region may rise by 4°F to as much as 12°F by the end of the twenty-first century, with more warming projected to occur in the northern part of the state. While projections of annual precipitation are uncertain, more precipitation falling as rain is very likely to occur as temperatures increase (BLM 2021a). By 2080 to 2090, the southwestern United States is projected to see a 10% to 20% decline in precipitation, primarily in winter and spring, with more precipitation falling as rain rather than snow compared with historical trends (Cayan 2013).

The U.S. Bureau of Reclamation et al. (2013) made the following projections through the end of the twenty-first century for the Upper Rio Grande Basin (southern Colorado to south-central New Mexico) based on the current and predicted future warming:

- There will be decreases in overall water availability by one-quarter to one-third.
- The seasonality of stream and river flows will change with summertime flows decreasing.
- Stream and river flow variability will increase. The frequency, intensity, and duration of both droughts and floods will increase.

Texas, Oklahoma, and Kansas are part of the Great Plains region, which will see increases in temperatures and more frequent drought in the future. Temperature increases and precipitation decreases will stress the region's primary water supply, the Ogallala Aquifer. Seventy percent (70%) of the land in this area is used for agriculture. Threats to the region associated with climate change include:

- pest migration as ecological zones shift northward,
- increases in weeds, and
- decreases in soil moisture and water availability (U.S. Bureau of Reclamation et al. 2013).

9.7.3 STATE CLIMATE CHANGE TRENDS AND PREDICTIONS

NOAA National Centers for Environmental Information released its Climate Summaries by state in 2022. The key messages bulleted below in Sections 9.7.3.1 through 9.7.3.4 represent climate summary information for each state within the BLM NMSO jurisdiction. More detailed climate discussions for each state can be found through the State Climate Summaries webpage and documents (NOAA 2022).

9.7.3.1 NEW MEXICO

- Average annual temperature has increased by almost 2°F since the beginning of the twentieth century, and the number of extremely hot days and warm nights has also increased. Historically unprecedented future warming is likely.
- The summer monsoon rainfall, which provides much needed water for agricultural and ecological systems, varies greatly from year to year and future trends in such precipitation are highly uncertain.
- Droughts are a serious threat in this water-scarce state. Drought intensity is projected to increase and snowpack accumulation is projected to decrease, which will pose a major challenge to New Mexico's environmental, agricultural, and human systems. Wildfire frequency and severity are projected to increase in New Mexico (Frankson, Kunkel, Stevens, and Easterling 2017).

9.7.3.2 OKLAHOMA

- Average annual temperature has increased by about 0.6°F since the beginning of the twentieth century. Winter warming has been characterized by the much below average occurrence of extremely cold days since 1990. Under a higher emissions pathway, historically unprecedented warming is projected during this century.
- Precipitation can vary greatly from year to year in this region of transition from humid to semi-arid conditions. Extreme precipitation events are projected to increase, which may increase the risk of flooding and associated increases in soil erosion and non-point source runoff into streams and lakes.
- The agricultural economy of Oklahoma makes the state particularly vulnerable to droughts, several of which have occurred in recent years. Higher temperatures will increase the rate of soil moisture depletion, leading to an increase in the intensity of naturally occurring future droughts (Frankson, Kunkel, Stevens, Champion, and Stewart 2017a).

9.7.3.3 KANSAS

- Average annual temperature has increased about 1.5°F since the beginning of the twentieth century, with greater warming in the winter and spring than in the summer and fall. The number of very cold nights has been much below average since 1990. Under a higher emissions pathway, historically unprecedented warming is projected during this century.
- Precipitation has varied greatly from year to year in this region of transition from humid conditions in the east of the state to semi-arid conditions in the west. Projected increases in winter precipitation and decreases in summer precipitation may result in both beneficial and negative impacts.

- The agricultural economy of Kansas makes the state vulnerable to droughts and heat waves, several of which occurred in the 1930s, 1950s, and in recent years. Projected increases in temperatures may increase the intensity of future droughts. The frequency of wildfire occurrence and severity is also projected to increase in Kansas (Frankson, Kunkel, Stevens, Easterling, Lin, and Shulski 2017).

9.7.3.4 TEXAS

- Mean annual temperature has increased by almost 1.5˚F since the beginning of the twentieth century. Under a higher emissions pathway, historically unprecedented warming is projected during this century, with associated increases in extreme heat events.
- Although projected changes in annual precipitation are uncertain, increases in extreme precipitation events are projected. Higher temperatures will increase soil moisture loss during dry spells, increasing the intensity of naturally occurring droughts.
- Future changes in the number of landfalling hurricanes in Texas are difficult to project. As the climate warms, increases in hurricane rainfall rates, storm surge height due to sea level rise, and the intensity of the strongest hurricanes are projected (Frankson, Kunkel, Stevens, Champion, and Stewart 2017b).

9.7.4 CUMULATIVE CLIMATE CHANGE SUMMARY

Existing conditions of climate change in any given location are the result of numerous complex factors, both natural and human caused. Natural factors contributing to the current condition of air resources include existing climate resulting from long-term atmospheric weather patterns, soil types, and vegetation types. Anthropogenic factors contributing to the current condition of air resources include long-term human habitation, growing human populations, transportation methods and patterns, recreational activities, economic patterns, and the presence of power plants and other industrial sources. The presence of natural resource (primarily oil and natural gas) extraction and processing on some BLM lands also impacts air quality and GHG emissions.

The IPCC concludes in AR5 that "cumulative emissions of CO_2 largely determine global mean surface warming by the late twenty-first century and beyond." Most aspects of climate change will persist for many centuries even if emissions of CO_2 are stopped. This represents a substantial multi-century climate change commitment created by past, present, and future emissions of CO_2 (IPCC 2013). Increasing concentrations may accelerate the rate of climate change in the future.

9.7.5 GLOBAL CARBON BUDGET DISCUSSION

Human activities are estimated to have caused approximately 1.0°C of global warming[2] above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at its current rate (high confidence) (IPCC 2018).

[2] Present level of global warming is defined as the average of a 30-year period centered on 2017 assuming the recent rate of warming continues.

Climate models project robust[3] differences in regional climate characteristics between the present day and global warming of 1.5°C, and between 1.5°C and 2.0°C. These differences include increases in

- mean temperature in most land and ocean regions (high confidence),
- hot extremes (temperatures) in most inhabited regions (high confidence),
- heavy precipitation in several regions (medium confidence), and
- drought and precipitation deficits in some regions (medium confidence) (IPCC 2018).

Limiting global warming requires limiting the total aggregate global anthropogenic emissions of CO_2 since the pre-industrial period, that is, staying within a total carbon budget (high confidence). Carbon budgeting, as defined by IPCC, refers to three concepts:

- an assessment of carbon cycle sources and sinks on a global level,
- the aggregate amount of global CO_2 emissions estimated to limit global surface temperatures to a given level above a reference period, and
- the distribution of the carbon budget defined under the regional, national, or subnational levels based on considerations of equity, cost, or efficiency (IPCC 2018).

There are at least 12 carbon budget studies with estimates that focus on limiting warming (50%, 66% probabilities, etc.) to below 1.5°C and 2.0°C (Carbon Brief 2018). Some of these studies are based on Earth System Models, some on combined observations and Earth System Models, and others on integrated assessment models, all of which use varying degrees of interim physics dynamics and data methodologies to provide carbon budget estimates.

Sizable uncertainties are reflected in these estimates as many different approaches are modeled into the carbon budget estimates. Some studies even show that the global carbon budget to limit warming below 1.5°C has already been expended. Attempting to show the relationship between a carbon budget and warming trends is not direct and linear and can vary drastically based on disagreement regarding

- the definition of “surface temperature,”
- the definition of the “pre-industrial” period,
- the observational temperature data sets that should be used,
- what happens to non-CO_2 factors that influence the climate, and
- whether Earth-system feedbacks like thawing permafrost are considered.

Drastic changes can also occur when there are net-negative emissions or when climate-cooling aerosols are reduced quickly (Carbon Brief 2018). Some uncertainty is common in scientific projections, but the uncertainty is substantial with regard to carbon budgets (IPCC 2018).

[3] Robust is used here to mean that at least two-thirds of climate models show the same sign of changes at the grid point scale, and that differences in large regions are statistically significant.

Using the global mean surface air temperature, as in IPCC's AR5, an estimate of 580 gigatonnes (Gt) CO_2 is used as the 2018 baseline for the remaining carbon budget to limit warming to 1.5°C with a 50% probability—a substantial uncertainty—through 2100. The IPCC 2018 Special Report states that the following uncertainties exist:

- the climate response from CO_2 and non-CO_2 emissions is ±400 Gt CO_2,
- the level of historic warming contributes ±250 Gt CO_2 of uncertainty,
- potential additional carbon release from future permafrost thawing and CH_4 release from wetlands would reduce budgets by up to 100 Gt CO_2 and another ±250 Gt CO_2 from future non-CO_2 mitigation efforts.

The uncertainties listed above could indicate the carbon budget could be -420 Gt CO_2 (meaning that the carbon budget to keep warming below 1.5°C may have already been expended). Similarly, the range of uncertainties listed above could result in a carbon budget that is up to 900 Gt CO_2 larger (meaning that the total carbon budget could be up to 1480 Gt to keep temperatures below 1.5°C by the end of the century). Therefore, although 580 Gt CO_2 represents a 50% chance to limit emissions to less than 1.5°C by the end of the century, the actual budget may be drastically different.

Table 7-3 of the BLM 2021 Specialist Report provides an estimate of the potential emissions associated with BLM fossil fuel authorizations in relation to IPCC carbon budgets. The BLM uses the long-term estimates of federal fossil fuel (oil, gas, and coal) emissions that were developed from the U.S. Energy Information Administration's (EIA's) 2022 Annual Energy Outlook (AEO). The projected annual emissions are added over the remaining time frame until the global emissions budget is estimated to be exhausted in order to show the portion of the budget that is consumed by federal emissions. The BLM-estimated emissions include direct emissions as well as transport and downstream combustion emissions. It is important to note that this comparison of BLM's estimated emissions from fossil fuel authorizations to global carbon budgets does not portray the full picture of carbon flux (amount emitted vs. amount stored/sequestered/offset) on public lands. In the specialist report, results of the carbon budget analysis are presented as the percent of the budget consumed by federal fossil fuel emissions and the difference in time it takes to consume the budget with and without federal fossil fuel emissions. The results reflect only the emissions side of the equation and may overestimate actual consumption of global carbon budgets resulting from BLM leases and authorizations. The U.S. Geological Survey (USGS) estimated that sequestration on federal land offset approximately 15% of CO_2 emissions resulting from the extraction and end-use combustion emissions of fossil fuels on federal lands (BLM 2021a).

10 GREENHOUSE GAS ANALYSIS AND METHODOLOGIES

Fossil fuel extraction, construction, and operation (well development), and processing and end-use production activities all contribute to air pollutants and GHG emissions in the FFO and CFO areas, especially San Juan, northwestern Sandoval, Eddy, Lea, and Chaves Counties as well as in parts of Oklahoma, Kansas and Texas. This includes midstream sources from the natural gas compressor stations and pipelines, gas plants, and petroleum refining as well as final downstream end-use by the consumer. Coal mining is also occurring in the FFO and OFO areas. Potash mining in the CFO area also contributes to air contaminant and GHG emissions.

Methodologies appropriate to GHG analysis are very different from those appropriate for air pollutant analysis. Air quality models used to predict concentrations and transport of air pollutants are not applicable to well-mixed, long-lived GHGs which impact the atmosphere on a global scale. Global climate models cannot currently be downscaled to accurately relate GHG emissions to regional or local-scale impacts. The GHG emissions data derived from analytical tools (such as emission calculators) may be used to compare project level emissions with state, national, and global emissions. However, such a comparison, while it provides context, may not always be useful information regarding impacts because project-level emissions are often orders of magnitude less than national emissions and because GHG impacts are inherently cumulative. Comparisons of GHG emissions among project alternatives and an analysis of the different project alternatives on the effects of climate change may provide more useful information. When modeling and analyzing GHG emissions, the primary sources of GHG emissions include:

- Fossil fuel combustion for construction and operation (well development) of oil and gas facilities. Vehicles driving to and from production sites, engines that drive drill rigs, etc., produce CO_2 in quantities that vary depending on the age, types, and conditions of the equipment, as well as the targeted formation, locations of wells with respect to processing facilities and pipelines, and other site-specific factors.
- Combustion of produced oil and gas. It is expected that development will produce marketable quantities of oil and/or gas. Combustion of the oil and/or gas would release CO_2 into the atmosphere. Fossil fuel combustion is the largest source of global CO_2.

  Estimated emissions for CO_2 are obtained from the calculator (Appendix F) for the drilling and operational phases of the well, as well as for other ancillary aspects of well development. These values include emissions from combustion engines used to construct and maintain the well.
- CH_4 releases from gas well development result from venting of natural gas during the well completion process, actuation of gas operated valves during well operations, and fugitive gas leaks along the infrastructure required for the production and transmission of gas. Combined, these represent a major source of global CH_4 emissions. These emissions have been estimated for various aspects of the energy sector, and starting in 2011, producers were required under 40 C.F.R. 98 to estimate and report their CH_4 emissions to the EPA (EPA 2022p). Estimated emissions for CH_4 are obtained from the calculator. These values include emissions from combustion engines used to construct and maintain the well (operations). No CH_4 emissions are predicted from ancillary construction operations.

Although incremental contributions to global GHGs from a proposed land management action cannot currently be translated into effects on climate change globally or in the area of any site-specific action, GHG emission volumes can be used as a proxy in determining impacts. In this way, we can estimate emissions from a project or land management action and then compare those activities with the regional, national, or global level of GHGs or GHGs emitted by a certain industry within a region.

The BLM has jurisdiction over federal oil and gas exploration, field operations, and well site-production on federal and Indian mineral estate. Once produced oil or gas leaves the well location (via pipeline or tanker truck), the BLM no longer has jurisdiction over these products. However, it is often necessary to estimate and analyze downstream GHG emissions more completely until the product is finally combusted (end-use).

For the purpose of NEPA analysis, EPA emission factors can be used to include a qualitative and quantitative analysis of possible GHG emissions that could occur as a result of reasonably foreseeable coal, oil, gas, or other development connected to federal land and resource management use. Estimates are made based on readily available data and reasonable assumptions about potential future development. More detailed emissions analysis can be qualitatively discussed and calculated at a site-specific level of analysis such as those that occur at an APD stage. Estimating direct and indirect GHG emissions attempt to provide a more complete GHG life cycle of a well from site inspection to possible emissions through combustion.

10.1 DIRECT OIL AND GAS EMISSIONS

Direct GHG emissions from future potential oil and gas well development and production can be estimated based on representative well characteristics. Total CO_2e, which includes direct emissions of CO_2, CH_4, and N_2O with applied GWPs, from an oil or gas producing well, is calculated.

10.1.1 WELL DEVELOPMENT GREENHOUSE GAS EMISSIONS

Increased GHG emissions can be connected to well development. The most substantial GHGs emitted by oil and gas development and production are CO_2 and CH_4. To facilitate quantification, most project-level analyses tend to assume that all wells would be developed concurrently and in the same year, though it is more likely that future potential development would not occur in this manner. Emission calculations for construction, operations, maintenance, and reclamation are included in Appendix F.

Construction emissions for either an oil or gas well include well pad construction (fugitive dust), heavy equipment combustive emissions, commuting vehicles, and wind erosion. Emissions from operations for an oil well include well workover operations (exhaust and fugitive dust), well site visits for inspection and repair, recompletion traffic, water and oil tank traffic, venting, compression and well pumps, dehydrators, and compression station fugitives. Operations emissions for a gas well include well workover operations (exhaust and fugitive dust), wellhead and compressor station fugitives, well site visits for inspection and repair, recompletions, compression, dehydrators, and compression station fugitives. Maintenance emissions for either an oil and gas well are for road travel and reclamation emission activities. Interim and final activities include emissions from truck traffic, a dozer, blade, and track hoe equipment.

Emissions are anticipated to be at their highest level during the construction and completion phases of implementation (approximately 30 days in duration) because these phases require the highest degree of earth-moving activity, heavy equipment use, and truck traffic, compared with the operations and maintenance phases of implementation. Emissions are anticipated to decline during operations and maintenance as the need for earth-moving and heavy equipment declines.

Table 13 provides past well completion data and associated GHG emissions (CO_2e) based on APD activity from the BLM AFMSS I system (BLM 2021b) and BLM AFMSS II system (BLM 2021c). GHG emissions (CO_2e) are calculated for the total number of well completions using a per-well emission factor based on activities during well construction and operation. The emissions provide a maximum emissions scenario as the number of wells each year is multiplied by approximately 1,229 and 1,253 metric tons of CO_2e/year in the Farmington Mancos Gallup Analysis Area (FMGAA) and Pecos District Office (PDO), respectively, which assumes all wells are gas wells for conservatism, since gas wells are estimated to have higher GHG emissions than oil wells.

Table 13. Well Completions and Estimated GHG Emissions based on APD Activity

Farmington Mancos Gallup Analysis Area	2016	2017	2018	2019	2020	2021	BLM RFD (2018–2037)	No. of Wells Developed after 2018[3]
Number of BLM well completions[1]	19	8	61	22	317	67	1,980	83
Metric tons of CO_2e/year	23,351	9,832	74,969	27,038	389,593	82,343	2,433,420	102,007
Pecos District Office	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**BLM RFD (2016–2035)**	**No. of Wells Developed after 2016 [3]**
Number of BLM well completions[2]	150	199	261	284	1,160	587	6,400	1163
Metric tons of CO_2e/year	187,950	249,347	327,033	355,852	1,453,480	735,511	8,019,200	1,457,239

Sources: BLM (2021b, 2021c)

Note: Methodology updated to use SNT.50 Reports from AFMSS. Wells completed from 2016 through 2019 are reported from BLM AFMSS 1 with run date April 2021 (BLM 2021b). Wells completed from 2020 through 2021 are reported from BLM AFMSS II with run date August 2022 (BLM 2021c). Counts for AFMSS I and AFMSS II used different methods, hence a marked increase in 2019. AFMSS II counts each single well completion separately.

[1] FMGAA number of BLM federal and non-federal wells in PDO RFD (2016–2037) is 3,400. FMGAA BLM wells includes completions from Farmington and Rio Puerco Field Offices.

[2] PDO number of BLM federal and non-federal wells in PDO RFD (2016–2037) is 16,000. PDO BLM wells includes completions from Carlsbad, Hobbs, and Roswell Field Offices.

[3] The number of wells developed after the start of the RFD for each respective field office (2018 for FFO and 2016 for PDO) are presented to disclose the current levels of development toward the total reasonably foreseeable development projections.

10.2 INDIRECT GREENHOUSE GAS EMISSIONS

Indirect GHG emissions are estimated based on speculative annual oil, gas, and/or natural gas liquids produced from oil and gas development. Indirect GHG emissions are calculated based on emission factors from 40 C.F.R. 98(c), which include default fuel heat values for crude oil and natural gas, as well as their respective default emission factors for CO_2, CH_4, and N_2O. Title 40 C.F.R. Part 98 Subpart C emission factors used in BLM GHG Indirect Greenhouse Gas Emissions are included below.

- Crude oil indirect emission factors:
  - Default heat content of fuel: 0.138 million British thermal units (mmBtu)/gallon
  - Emissions factors per unit of energy:
    - 74.54 kg CO_2/mmBtu
    - 0.003 kg CH_4/mmBtu
    - 0.0006 kg N_2O/mmBtu
- Gas indirect emission factors:
  - Default heat content of fuel: 0.001026 mmBtu/standard cubic foot (scf)

- Emissions factors per unit of energy:
  - 53.06 kg CO_2/mmBtu
  - 0.001 kg CH_4/mmBtu
  - 0.0001 kg N_2O/mmBtu

10.2.1 OIL AND GAS PRODUCTION (DOWNSTREAM EMISSIONS [END-USE])

Estimates of production (or downstream/end use) GHG emissions are dependent on projected oil and gas production volumes. The BLM does not direct or regulate the end use of produced oil and/or gas. The challenge for estimating downstream emissions comes with understanding when and how oil and gas would be distributed and used for energy. It can be reasonably assumed that oil and gas produced on leases would be combusted primarily for electricity generation, transportation, industry, agriculture, commercial, and residential uses. From this assumption, the BLM provides potential GHG emissions estimates using currently available GHG emissions data.

Table 14 details the latest oil and gas production volumes and other lands within the jurisdiction of the BLM in New Mexico, Kansas, Oklahoma, and Texas, as well as the United States as a whole.

Table 14. 2019 Oil and Gas Production

Location	Oil (Mbbl)	% U.S. Total	Gas (MMcf)	% U.S. Total
United States	4,470,528	100	40,982,458	100
New Mexico	329,483	7.37	1,852,719	4.52
Federal leases NM[(1)]	121,556	2.72	1,046,482	2.55
Kansas	33,193	0.74	183,097	0.44
Federal leases KS[(2)]	165	0.004	3,030	0.007
Oklahoma	211,808	4.74	3,175,008	7.74
Federal leases OK[(2)]	935	0.02	13,966	0.03
Texas	1,850,715	41.40	10,355,453	25.27
Federal leases TX[(2)]	396	0.009	26,166	0.06

Sources: Office of Natural Resources Revenue (ONRR) (2020); EIA 2020

Notes: Mbbl = thousand barrels; MMcf = million cubic feet

[(1)] Federal leases in New Mexico refers to the BLM oil and gas activity in the following counties: Eddy, Lea, Chaves, Roosevelt, McKinley, Rio Arriba, San Juan, and Sandoval. The New Mexico San Juan Basin production values are 4,891 Mbbl oil and 419,696 Mbbl gas. The New Mexico Permian Basin production values are 154,266 Mbbl oil and 326,451 Mbbl gas.

[(2)] Federal leases in Oklahoma, Kansas, and Texas refers to BLM oil and gas activity in any county reporting federal leases to ONRR.

10.3 UNCERTAINTIES OF GREENHOUSE GAS CALCULATIONS

Although an analysis may present a quantified estimate of potential GHG emissions associated with reasonably foreseeable oil and gas development, there is significant uncertainty in GHG emission estimates with regard to eventual production volumes and variability in flaring, construction, and transportation. A rough estimate was possible using publicly available information and using estimates from future production for reasonably foreseeable development.

Also, there is uncertainty with regard to the net effects of reasonably foreseeable oil and gas development on climate; that is, while BLM actions may contribute to the climate change, the specific effects of those actions on global climate are speculative given the current state of the science. Inconsistencies in the results of scientific models designed to predict climate change on regional or local scales limits the ability to quantify potential future impacts of decisions made at this level and determining the significance of any discrete amount of GHG emissions is beyond the limits of existing science.

10.4 REASONABLY FORESEEABLE DEVELOPMENT SCENARIOS

10.4.1 FARMINGTON FIELD OFFICE

Table 15 provides the reasonably foreseeable future GHGs (CO_2e emissions) associated with end-use oil and gas combustion emissions for the 2018 Mancos Gallop RFD scenario from federal, state (fee), and Indian minerals in the planning area. Total cumulative well development will result in 3,200 new wells from 2018 to 2037, of which 1,980 are estimated to be federal. The methodology for estimating new well development, as well as the volumes for oil and gas, is described in the Mancos Gallup 2018 RFD (Crocker and Glover 2018).

CO_2e emissions from downstream/end-use combustion of oil and gas products are estimated annually and cumulatively for Mancos Gallup and Rio Puerco BLM development and an all development (federal and non-federal) well production development scenario (see Table 15). Under the Mancos Gallup all development scenario (includes federal, Indian, state, and fee minerals), cumulative emissions during the 20-year period is estimated to produce 398.4 million metric tons (MMT) of CO_2e from the end-use combustion of products from 3,200 wells. The range of annual CO_2e emissions from Mancos Gallup is 15.3 MMT/year in 2024 during the development of 126 additional oil and gas wells to 28.5 MMT/year of CO_2e in 2037 when 253 annual oil and gas wells will be added. Under the Rio Puerco all development scenario (includes federal, Indian, state, and fee minerals), cumulative emissions during the 20-year period is estimated to produce 3.88 million metric tons (MMT) of CO_2e from the end-use combustion of products from 200 wells. The range of annual CO_2e emissions from Rio Puerco is 0.03 MMT/year in 2020 during the development of 7 additional oil and gas wells to 0.32 MMT/year of CO_2e in 2039 when 13 annual oil and gas wells will be added.

Table 15. Estimated Cumulative Downstream/End-Use GHG Emissions Resulting from Oil and Gas Production for BLM 2018 Mancos Gallup RFD Scenario and BLM 2019 Rio Puerco RFD Scenario – Federal and All in Planning Area

Mancos Gallup

Federal Wells in the Planning Area

(federal development only)

Year	Number of Wells	Annual CO_2 (MT) Oil	Annual CH_4 (MT) Oil	Annual N_2O (MT) Oil	Annual CO_2 (MT) Gas	Annual CH_4 (MT) Gas	Annual N_2O (MT) Gas	Annual CO_2e (MMT) Oil and Gas	CO_2e % of Total RFD
2018	41	2,150,121.90	86.54	17.31	12,973,881.29	244.51	24.45	15.14	6.1%
2019	48	2,351,067.87	94.62	18.92	10,715,391.22	201.95	20.19	13.09	5.3%
2020	53	2,521,871.95	101.50	20.30	9,033,960.28	170.26	17.03	11.57	4.7%
2021	59	2,702,723.32	108.78	21.76	7,849,994.12	147.95	14.79	10.57	4.3%
2022	65	2,873,527.40	115.65	23.13	7,044,101.19	132.76	13.28	9.93	4.0%
2023	72	3,034,284.18	122.12	24.42	6,646,129.37	125.26	12.53	9.70	3.9%
2024	78	3,215,135.55	129.40	25.88	6,397,396.98	120.57	12.06	9.63	3.9%
2025	84	3,406,034.23	137.08	27.42	6,268,056.14	118.13	11.81	9.69	3.9%
2026	90	3,606,980.20	145.17	29.03	6,297,904.03	118.69	11.87	9.92	4.0%
2027	96	3,817,973.47	153.66	30.73	6,437,194.17	121.32	12.13	10.27	4.2%
2028	103	4,049,061.34	162.96	32.59	6,685,926.55	126.01	12.60	10.76	4.3%
2029	109	4,280,149.21	172.26	34.45	7,014,253.30	132.19	13.22	11.32	4.6%
2030	112	4,461,000.58	179.54	35.91	7,342,580.05	138.38	13.84	11.83	4.8%
2031	120	4,722,230.34	190.05	38.01	7,770,399.76	146.45	14.64	12.52	5.1%
2032	127	4,983,460.11	200.57	40.11	8,238,016.65	155.26	15.53	13.25	5.4%
2033	133	5,244,689.87	211.08	42.22	8,715,582.83	164.26	16.43	13.99	5.7%
2034	139	5,515,966.93	222.00	44.40	9,232,946.19	174.01	17.40	14.78	6.0%
2035	145	5,797,291.29	233.32	46.66	9,770,208.15	184.14	18.41	15.60	6.3%
2036	150	6,078,615.66	244.65	48.93	10,347,267.28	195.01	19.50	16.46	6.7%
2037	156	6,349,892.72	255.56	51.11	10,924,326.42	205.89	20.59	17.31	7.0%
TOTAL	1980	81,182,172.73	3,267.33	653.47	165,725,414.57	3,123.36	312.34	247.36	100

Source: Crocker and Glover (2018)

Rio Puerco Federal Wells in the Planning Area (federal development only)									
Year	**Number of Wells**	**Annual CO_2 (MT) Oil**	**Annual CH_4 (MT) Oil**	**Annual N_2O (MT) Oil**	**Annual CO_2 (MT) Gas**	**Annual CH_4 (MT) Gas**	**Annual N_2O (MT) Gas**	**Annual CO_2e (MMT) Oil and Gas**	**CO_2e % of Total RFD**
2020	5	19,916.76	0.80	0.16	1,306.55	0.02	0.00	0.02	0.8%
2021	5	36,118.03	1.45	0.29	2,340.90	0.04	0.00	0.04	1.5%
2022	5	43,678.62	1.76	0.35	2,558.66	0.05	0.00	0.05	1.8%
2023	5	63,336.16	2.55	0.51	3,756.33	0.07	0.01	0.07	2.7%
2024	5	66,792.43	2.69	0.54	3,756.33	0.07	0.01	0.07	2.8%
2025	5	83,252.92	3.35	0.67	4,736.24	0.09	0.01	0.09	3.5%
2026	6	90,986.33	3.66	0.73	4,899.56	0.09	0.01	0.10	3.8%
2027	6	98,546.92	3.97	0.79	5,008.44	0.09	0.01	0.10	4.1%
2028	6	104,292.97	4.20	0.84	5,443.96	0.10	0.01	0.11	4.4%
2029	6	115,957.88	4.67	0.93	6,151.67	0.12	0.01	0.12	4.9%
2030	6	125,592.24	5.05	1.01	6,750.51	0.13	0.01	0.13	5.3%
2031	7	139,762.95	5.63	1.13	7,839.30	0.15	0.01	0.15	5.9%
2032	7	151,039.03	6.08	1.22	8,764.77	0.17	0.02	0.16	6.3%
2033	7	160,414.16	6.46	1.29	9,472.48	0.18	0.02	0.17	6.7%
2034	8	168,104.37	6.77	1.35	10,071.32	0.19	0.02	0.18	7.1%
2035	8	174,757.69	7.03	1.41	10,561.27	0.20	0.02	0.19	7.4%
2036	8	180,719.76	7.27	1.45	10,996.79	0.21	0.02	0.19	7.6%
2037	8	186,076.97	7.49	1.50	11,323.43	0.21	0.02	0.20	7.8%
2038	8	185,169.70	7.45	1.49	10,942.35	0.21	0.02	0.20	7.8%
2039	8	185,558.53	7.47	1.49	10,615.71	0.20	0.02	0.20	7.8%
TOTAL	129	2,380,074.42	95.79	19.16	137,296.57	2.59	0.26	2.53	100%

Source: Crocker et al. (2019)

Mancos Gallup All Wells in the Planning Area (including federal, Indian, state, and fee minerals)									
Year	**Number of Wells**	**Annual CO_2 (MT) Oil**	**Annual CH_4 (MT) Oil**	**Annual N_2O (MT) Oil**	**Annual CO_2 (MT) Gas**	**Annual CH_4-(MT) Gas**	**Annual N_2O-(MT) Gas**	**Annual CO_2e (MMT) Oil and Gas**	**CO_2e % of Total RFD**
2018	67	3,338,757.52	134.37	26.87	20,611,035.17	388.45	38.84	23.98	6.0%
2019	76	3,631,244.43	146.15	29.23	17,054,335.40	321.42	32.14	20.72	5.2%
2020	86	3,868,431.00	155.69	31.14	14,426,592.28	271.89	27.19	18.32	4.6%
2021	96	4,116,418.43	165.67	33.13	12,583,813.17	237.16	23.72	16.73	4.2%
2022	106	4,347,556.53	174.98	35.00	11,359,304.15	214.08	21.41	15.73	4.0%
2023	116	4,572,214.13	184.02	36.80	10,767,546.13	202.93	20.29	15.37	3.9%

Mancos Gallup All Wells in the Planning Area (including federal, Indian, state, and fee minerals)									
Year	**Number of Wells**	**Annual CO_2 (MT) Oil**	**Annual CH_4 (MT) Oil**	**Annual N_2O (MT) Oil**	**Annual CO_2 (MT) Gas**	**Annual CH_4-(MT) Gas**	**Annual N_2O-(MT) Gas**	**Annual CO_2e (MMT) Oil and Gas**	**CO_2e % of Total RFD**
2024	126	4,815,017.15	193.79	38.76	10,436,281.41	196.69	19.67	15.28	3.8%
2025	136	5,081,582.03	204.52	40.90	10,312,050.33	194.35	19.43	15.42	3.9%
2026	146	5,369,748.60	216.12	43.22	10,438,186.79	196.72	19.67	15.84	4.0%
2027	156	5,676,924.66	228.48	45.70	10,756,930.42	202.73	20.27	16.46	4.1%
2028	166	6,019,095.46	242.25	48.45	11,244,164.48	211.91	21.19	17.30	4.3%
2029	176	6,367,746.77	256.28	51.26	11,849,096.87	223.32	22.33	18.25	4.6%
2030	180	6,264,058.65	252.11	50.42	12,471,341.04	235.04	23.50	18.77	4.7%
2031	194	6,915,133.64	278.31	55.66	13,303,994.11	250.73	25.07	20.26	5.1%
2032	204	7,354,944.09	296.01	59.20	14,174,156.04	267.13	26.71	21.57	5.4%
2033	214	7,765,376.24	312.53	62.51	15,053,518.25	283.71	28.37	22.86	5.7%
2034	224	8,193,521.78	329.76	65.95	15,986,394.55	301.29	30.13	24.22	6.1%
2035	234	8,615,618.84	346.75	69.35	16,900,380.33	318.51	31.85	25.56	6.4%
2036	244	9,028,211.15	363.36	72.67	17,982,094.38	338.90	33.89	27.06	6.8%
2037	253	9,438,211.27	379.86	75.97	19,042,087.06	358.88	35.89	28.53	7.2%
TOTAL	3200	120,779,812.34	4,861.01	972.20	276,753,302.38	5,215.86	521.59	398.23	100

Source: Crocker and Glover (2018)

Rio Puerco All Wells in the Planning Area (including federal, Indian, state, and fee minerals)									
Year	**Number of Wells**	**Annual CO_2 (MT) Oil**	**Annual CH_4 (MT) Oil**	**Annual N_2O (MT) Oil**	**Annual CO_2 (MT) Gas**	**Annual CH_4-(MT) Gas**	**Annual N_2O-(MT) Gas**	**Annual CO_2e (MMT) Oil and Gas**	**CO_2e % of Total RFD**
2020	7	29,594.32	1.19	0.24	1,633.19	0.03	0.00	0.03	0.8%
2021	7	51,714.45	2.08	0.42	2,939.74	0.06	0.01	0.05	1.4%
2022	7	70,291.91	2.83	0.57	4,028.53	0.08	0.01	0.07	1.9%
2023	8	92,584.85	3.73	0.75	5,280.64	0.10	0.01	0.10	2.5%
2024	8	111,335.12	4.48	0.90	6,314.99	0.12	0.01	0.12	3.0%
2025	8	127,320.37	5.12	1.02	7,186.02	0.14	0.01	0.13	3.5%
2026	9	141,102.25	5.68	1.14	7,893.74	0.15	0.01	0.15	3.9%
2027	9	153,199.20	6.17	1.23	8,492.57	0.16	0.02	0.16	4.2%
2028	10	169,659.69	6.83	1.37	9,581.36	0.18	0.02	0.18	4.6%
2029	10	183,311.96	7.38	1.48	10,506.84	0.20	0.02	0.19	5.0%
2030	10	194,804.06	7.84	1.57	11,268.99	0.21	0.02	0.21	5.3%
2031	11	211,653.38	8.52	1.70	12,248.90	0.23	0.02	0.22	5.8%

Rio Puerco All Wells in the Planning Area (including federal, Indian, state, and fee minerals)									
Year	**Number of Wells**	**Annual CO_2 (MT) Oil**	**Annual CH_4 (MT) Oil**	**Annual N_2O (MT) Oil**	**Annual CO_2 (MT) Gas**	**Annual CH_4-(MT) Gas**	**Annual N_2O-(MT) Gas**	**Annual CO_2e (MMT) Oil and Gas**	**CO_2e % of Total RFD**
2032	11	226,299.33	9.11	1.82	13,011.05	0.25	0.02	0.24	6.2%
2033	11	239,389.95	9.63	1.93	13,609.89	0.26	0.03	0.25	6.5%
2034	12	250,882.05	10.10	2.02	14,154.29	0.27	0.03	0.27	6.9%
2035	12	261,121.25	10.51	2.10	14,644.24	0.28	0.03	0.28	7.1%
2036	12	270,323.57	10.88	2.18	15,025.32	0.28	0.03	0.29	7.4%
2037	12	278,705.03	11.22	2.24	15,351.96	0.29	0.03	0.30	7.6%
2038	13	293,480.59	11.81	2.36	15,950.79	0.30	0.03	0.31	8.0%
2039	13	306,614.42	12.34	2.47	16,440.75	0.31	0.03	0.32	8.3%
TOTAL	200	3,663,387.74	147.44	29.49	205,563.78	3.87	0.39	3.88	100%

Source: Crocker et al. (2019)

Over the 20-year period, Mancos Gallup cumulative federal wells would produce 247.4 MMT of CO_2e emissions from end-use combustion of oil and gas fossil fuels from 1,980 wells. The range of Mancos Gallup annual CO_2e emissions is 9.6 MMT/year in 2024 during the development of 78 oil and gas wells to 17.3 MMT/year of CO_2e in 2037 during the development of 156 annual oil and gas wells. Table 23It would represent a contribution of 1.11% to 2.00% respectively to BLM's annual 2030 future estimated downstream (end-use) GHG emissions (Table 23). It should be noted that Table 23 also includes emissions from coal which produces 50% to 60% more CO_2 emissions than natural gas.

10.4.2 PECOS DISTRICT OFFICE PLANNING AREA

Table 16 provides the reasonably foreseeable future GHGs (CO_2e emissions) associated with end-use oil and gas combustion emissions for PDO from federal, state (fee) as well as Indian minerals in the planning area. The PDO federal planning area includes oil and gas well development from CFO, Roswell Field Office as well as Hobbs Field Office. Total cumulative well development will result in 16,000 new wells from 2016 to 2035, of which 6,400 are estimated to be federal. The methodology for estimating new well development as well as the volumes for oil and gas is described in Engler et al. (2012) and Engler and Cather (2014).

CO_2e emissions from downstream/end-use combustion of oil and gas products are estimated annually and cumulatively for BLM development and for an all development (federal and non-federal) well production scenario (see Table 16). Under the all development scenario (includes federal, Indian, state and fee minerals), cumulative emissions during the 20-year period is estimated to produce 5,597 MMT of CO_2e from the end-use combustion of oil and gas from 16,000 wells. The range of annual CO_2e emissions is 97.7 MMT/year in 2016 to 597.7 MMT/year of CO_2e in 2035 when additional wells are added to production.

Over the 20-year period, cumulative federal wells could produce 1,168.5 MMT of CO_2e emissions from end-use combustion of oil and gas fossil fuels from 6,400 wells. The range of annual CO_2e emissions is

48.1 MMT/year in 2016 to 70.1 MMT/year of CO_2e in 2035.Table 23 It would represent a contribution of 5.55% to 8.09% respectively to BLM's 2030 annual future estimated GHG emissions (Table 23). It should be noted that Table 23 also includes emissions from coal, which produces 50% to 60% more CO_2 emissions than natural gas.

Table 16. Estimated Cumulative Downstream/End-Use GHG Emissions Resulting from Oil and Gas Production for BLM 2018 RFD PDO Scenario – Federal and All Wells in Planning Area

Federal Wells in the Planning Area

Year	Annual CO_2 (MT) Oil	Annual CH_4 (MT) Oil	Annual N_2O (MT) Oil	Annual CO_2 (MT) Gas	Annual CH_4 (MT) Gas	Annual N_2O (MT) Gas	Annual CO_2e (MMT) Oil and Gas	CO_2e % of Total RFD
2016	32,322,159.61	1,300.87	260.17	15,640,292.47	294.77	29.48	48.09	4.1%
2017	32,965,186.72	1,326.74	265.35	15,958,669.93	300.77	30.08	49.05	4.2%
2018	33,628,308.43	1,353.43	270.69	16,277,047.38	306.77	30.68	50.04	4.3%
2019	34,301,477.44	1,380.53	276.11	16,605,374.13	312.95	31.30	51.04	4.4%
2020	34,984,693.74	1,408.02	281.60	16,933,700.88	319.14	31.91	52.06	4.5%
2021	35,688,004.64	1,436.33	287.27	17,271,976.93	325.52	32.55	53.10	4.5%
2022	36,401,362.84	1,465.04	293.01	17,620,202.27	332.08	33.21	54.16	4.6%
2023	37,124,768.34	1,494.15	298.83	17,968,427.61	338.64	33.86	55.24	4.7%
2024	37,868,268.44	1,524.08	304.82	18,326,602.25	345.39	34.54	56.34	4.8%
2025	38,621,815.84	1,554.41	310.88	18,694,726.18	352.33	35.23	57.47	4.9%
2026	39,395,457.83	1,585.54	317.11	19,072,799.41	359.46	35.95	58.62	5.0%
2027	40,189,194.42	1,617.49	323.50	19,450,872.64	366.58	36.66	59.80	5.1%
2028	40,992,978.31	1,649.84	329.97	19,838,895.16	373.90	37.39	60.99	5.2%
2029	41,806,809.49	1,682.59	336.52	20,236,866.98	381.40	38.14	62.21	5.3%
2030	42,650,782.58	1,716.56	343.31	20,644,788.09	389.08	38.91	63.46	5.4%
2031	43,494,755.66	1,750.53	350.11	21,052,709.21	396.77	39.68	64.72	5.5%
2032	44,368,870.64	1,785.71	357.14	21,470,579.62	404.65	40.46	66.01	5.6%
2033	45,253,032.92	1,821.29	364.26	21,908,348.62	412.90	41.29	67.34	5.8%
2034	46,157,289.79	1,857.69	371.54	22,346,117.62	421.15	42.11	68.68	5.9%
2035	47,081,641.26	1,894.89	378.98	22,793,835.91	429.59	42.96	70.06	6.0%
TOTAL	785,306,906.24	31,606.13	6,321.23	380,092,934.68	7,163.46	716.35	1,168.47	100

All Wells in the Planning Area

Year	Annual CO_2 (MT) Oil	Annual CH_4 (MT) Oil	Annual N2O(MT) Oil	Annual CO_2 (MT) Gas	Annual CH_4-(MT) Gas	Annual N_2O (MT) Gas	Annual CO_2e (MMT) Oil and Gas	CO_2e % of Total RFD
2016	65,407,913.92	2,632.46	526.49	32,056,629.99	604.16	60.42	97.72	1.7%

All Wells in the Planning Area								
Year	Annual CO_2 (MT) Oil	Annual CH_4 (MT) Oil	Annual N2O(MT) Oil	Annual CO_2 (MT) Gas	Annual CH_4-(MT) Gas	Annual N_2O (MT) Gas	Annual CO_2e (MMT) Oil and Gas	CO_2e % of Total RFD
2017	71,948,705.31	2,895.71	579.14	35,260,303.13	664.54	66.45	107.49	1.9%
2018	79,142,571.11	3,185.24	637.05	38,792,303.02	731.10	73.11	118.24	2.1%
2019	87,059,842.41	3,503.88	700.78	42,672,528.25	804.23	80.42	130.07	2.3%
2020	95,760,803.00	3,854.07	770.81	46,940,776.01	884.67	88.47	143.08	2.6%
2021	105,345,925.87	4,239.84	847.97	51,626,894.17	972.99	97.30	157.38	2.8%
2022	115,875,494.81	4,663.62	932.72	56,790,578.52	1,070.31	107.03	173.12	3.1%
2023	127,460,030.10	5,129.86	1,025.97	62,471,626.23	1,177.38	117.74	190.43	3.4%
2024	140,210,052.03	5,643.01	1,128.60	68,719,783.78	1,295.13	129.51	209.48	3.7%
2025	154,226,033.58	6,207.11	1,241.42	75,594,746.95	1,424.70	142.47	230.42	4.1%
2026	169,648,636.94	6,827.82	1,365.56	83,146,262.21	1,567.02	156.70	253.46	4.5%
2027	186,618,524.28	7,510.81	1,502.16	91,463,873.22	1,723.78	172.38	278.81	5.0%
2028	205,276,357.79	8,261.73	1,652.35	100,607,275.75	1,896.10	189.61	306.69	5.5%
2029	225,813,036.14	9,088.26	1,817.65	110,675,962.76	2,085.86	208.59	337.37	6.0%
2030	248,389,316.10	9,996.89	1,999.38	121,739,579.32	2,294.38	229.44	371.10	6.6%
2031	273,226,238.25	10,996.49	2,199.30	133,917,516.97	2,523.89	252.39	408.21	7.3%
2032	300,554,890.46	12,096.39	2,419.28	147,309,268.67	2,776.28	277.63	449.04	8.0%
2033	330,606,360.59	13,305.86	2,661.17	162,034,225.96	3,053.79	305.38	493.93	8.8%
2034	363,661,973.00	14,636.25	2,927.25	178,241,628.27	3,359.25	335.92	543.33	9.7%
2035	400,033,193.94	16,100.07	3,220.01	196,060,816.45	3,695.08	369.51	597.66	10.7%
TOTAL	3,746,275,946.92	150,775.80	30,155.16	1,836,122,579.62	34,604.65	3,460.46	5,597.05	100

Sources: Engler et al. (2012); Engler and Cather (2014)

Table 17 shows historical U.S., New Mexico, and BLM NMSO federal production in the major oil and gas basins within New Mexico and their associated end-use combustion GHG emissions during calendar years 2015 through 2019. Production of oil and gas on federal land has varied over the 5-year period due to market conditions, technological advances, and pipeline and storage infrastructure availability. In 2015, total CO_2e end-use emissions resulting from oil and gas production in the United States were 3,288.42 MMT. New Mexico 2015 GHG emissions associated with oil and gas production end-use were 134.87 MMT, which is 4.11% of national emissions in 2015.

GHG emissions from oil and gas production in the BLM PDO planning area in 2015 were 47.18 MMT of CO_2e, which is 1.44% of national oil and gas GHG emissions and 35.0% of New Mexico oil and gas GHG emissions from production in 2015. GHG end-use emissions from the BLM PDO planning area increased to 104.76 MMT/year of CO_2e in 2019.

GHG emissions from oil and gas production in the BLM FFO planning area in 2015 were 30.42 MMT of CO_2e, which is 0.93% of national oil and gas GHG emissions and 22.6% of New Mexico oil and gas GHG emissions from production in 2015. GHG end-use emissions from the BLM PDO planning area decreased to 24.99 MMT/year of CO_2e in 2019.

Table 17. Historical Federal Oil and Gas Production New Mexico

Oil and Gas Production	2015	2016	2017	2018	2019
U.S. oil production (Mbbl)	3,447,970	3,239,657	3,420,545	4,001,892	4,470,528
New Mexico oil production (Mbbl)	148,095	146,634	172,154	248,879	329,483
BLM PDO oil production (Mbbl)	72,630	71,479	84,151	124,205	162,908
BLM FFO oil production (Mbbl)	6,832	5,344	4,914	5,042	4,891
U.S. gas production (MMcf)	32,914,647	32,591,578	33,292,113	37,325,539	40,892,458
New Mexico gas production (MMcf)	1,296,793	1,282,666	1,323,019	1,540,984	1,852,719
BLM PDO gas production (MMcf)	287,963	308,463	352,421	478,919	626,451
BLM FFO gas production (MMcf)	503,804	470,078	440,776	438,842	419,696
GHG Emissions					
Total U.S. oil and gas GHG emissions (MMT) CO_2e	3,288.42	3,180.51	3,297.10	3,768.92	4,166.46
Total New Mexico oil and gas GHG emissions (MMT CO_2e)	134.87	133.47	146.73	191.87	243.80
Total PDO oil and gas GHG emissions (MMT CO_2e)	47.18	47.80	55.69	79.94	104.76
Total FFO oil and gas GHG emissions (MMT CO_2e)	30.42	27.93	26.15	26.10	24.99

Note: Data total for BLM PDO and FFO includes data from both federal and mixed exploratory land classes.

GHG emissions from oil and gas production in the BLM OFO planning area in 2015 were 3.8 MMT of CO_2e, which is 0.12% of national oil and gas GHG emissions and 0.30% of Texas, Oklahoma, and Kansas oil and gas GHG emissions combined (Table 18) from production in 2015. GHG end-use emissions from the BLM OFO planning area decreased to 2.9 MMT/year of CO_2e in 2019.

Table 18. Historical Federal Oil and Gas Production for Oklahoma, Kansas, and Texas (OFO)

Oil and Gas Production	2015	2016	2017	2018	2019
U.S. oil production (Mbbl)	3,447,970	3,239,657	3,420,545	4,001,892	4,470,528
Oklahoma oil production (Mbbl)	166,468	155,228	165,955	199,557	211,808
Oklahoma federal oil production (Mbbl)	1059.219	857.562	613.381	532.066	834.788
Texas oil production (Mbbl)	1,260,755	1,167,369	1,273,558	1,608,926	1,850,715
Texas federal oil production (Mbbl)	270.4	260.107	421.923	448.227	314.627

Oil and Gas Production	2015	2016	2017	2018	2019
Kansas oil production (Mbbl)	45,481	37,944	35,825	34,715	33,193
Kansas federal oil production (Mbbl)	154	139	127	127	110
BLM OFO (Kansas, Oklahoma, Texas) oil production (Mbbl)(1)	1,484	1,257	1,163	1,107	1,259
U.S. gas production (MMcf)	32,914,647	32,591,578	33,292,113	37,325,539	40,892,458
Oklahoma gas production (MMcf)	2,499,599	2,468,312	2,513,897	2,875,787	3,175,008
Oklahoma federal gas production (MMcf)	19,673	17,862	14,757	13,710	13,966
Texas gas production (MMcf)	8,799,465	8,156,296	8,079,974	9,109,174	10,355,453
Texas federal gas production (MMcf)	34,115	33,348	30,148	27,002	26,166
Kansas gas production (MMcf)	284,184	244,795	219,639	201,391	183,097
Kansas federal gas production (MMcf)	4,418	4,137	3,865	3,743	3,030
BLM OFO (Kansas, Oklahoma, Texas) gas production (MMcf)	58,206	55,347	48,771	44,454	43,163
GHG Emissions					
Total U.S. oil and gas GHG emissions (MMT) CO_2e	3,288.42	3,180.51	3,297.10	3,768.92	4,166.46
Total Kansas, Oklahoma, Texas oil and gas GHG emissions (MMT CO_2e)	1,269.66	1,182.14	1,228.86	1,463.14	1,655.83
Total OFO (Kansas, Oklahoma, Texas) oil and gas GHG emissions (MMT CO_2e)	3.8	3.6	3.2	2.9	2.9

Note: Emissions factors for oil and gas production from Subpart C are used.

(1) OFO includes federal oil and gas activity for Oklahoma, Kansas, and Texas.

10.5 GLOBAL, NATIONAL, AND STATE GREENHOUSE GAS EMISSIONS

It is useful to compare the relative and absolute contributions to climate change of different GHG emissions, as well as emissions from different regions/countries or sources/sectors. There are several different metrics that can be used for this comparison. A GHG emission inventory is used to identify and quantify the anthropogenic GHG emissions from different regions/countries or sources/sectors. Using the GWP concept, GHG emissions are often reported in terms of CO_2e. The World Resources Institute's Climate Analysis Indicators Tool provides data on GHG emissions from 186 countries and all 50 states. In 1990, total global GHG emissions were 34,964 MMT CO_2e; In 2017, total global GHG emissions were 49,947 MMT CO_2e, including land-use change and forestry. From 1990 to 2017, global GHG emissions increased at an annual rate of 3.3%. Electricity generation, manufacturing/construction, and transportation account for roughly 31%, 13%, and 15% of total global GHG emissions, respectively (World Resources Institute 2017).

To meet the obligations of the United Nations Framework Convention on Climate Change, the EPA publishes the national GHG emissions inventory on an annual basis (EPA 2022p). The lowest GHG emissions since reporting began, 6,373 MMT of CO2e, occurred in 1991, and the peak GHG emissions occurred about 16 years later in 2007, 7,417 MMT CO_2e. The largest source of GHG emissions from human activities in the United States is from burning of fossil fuels for electricity, heat, and transportation. Total U.S. emissions have decreased by 6.6% from 1990 to 2020; 2005 emissions were 15.8% above 1990 levels. The latest national GHG emissions are for calendar year 2020, in which total gross U.S. GHG emissions were reported at 5,981.4 MMT CO_2e (Figure 18). Emissions decreased from 2019 to 2020 by 543.4 MMT CO_2e. Net emissions (including sinks) were 5,222.4 MMT CO_2e. The decline from 2019 to 2020 reflects the combined impacts of many long-term trends, including population, economic growth, energy market trends, technological changes including energy efficiency, and carbon intensity of energy fuel choices. Figure 18 illustrates U.S. GHG emissions (MMT/year) from gas between 1990 through 2020 (EPA 2022p).

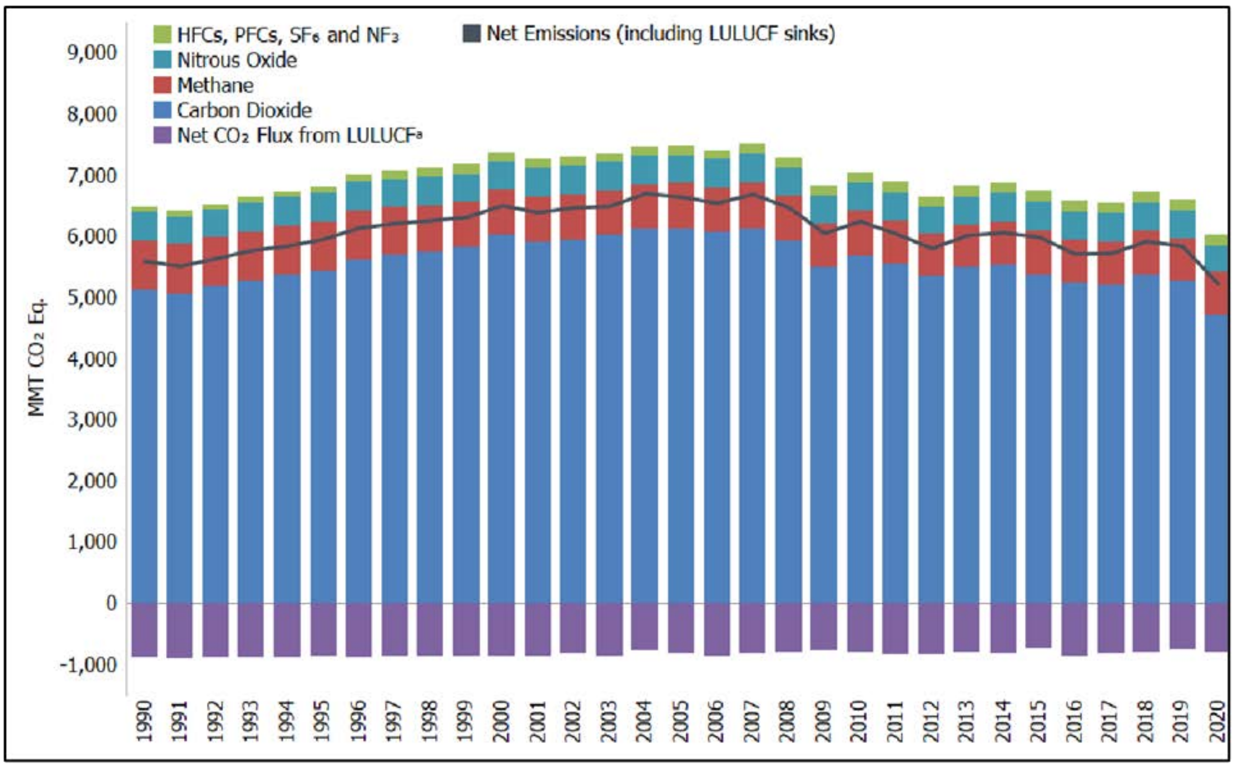


Figure 18. U.S. GHG emissions from gas between 1990 to 2020

Source: EPA (2022p)

GHG emissions can be generated from a myriad of sources. The Inventory on Greenhouse Gas Emissions produced annually by the EPA categorizes these emissions in five economic sectors: transportation, electricity generation, industry, agriculture, and commercial and residential.

- **Transportation –** GHG emissions are a result of burning fossil fuel for use in cars, trucks, ships, trains, and planes.
- **Electricity Generation –** GHG emissions in this sector are primarily from fuel methods used to generate electricity, coal, natural gas, and other fuels.
- **Industry –** GHG emissions from the industry sector are the result of the burning of fossil fuels for energy as well as emissions from certain chemical reactions necessary to produce goods from raw materials.

- **Commercial and Residential –** These GHG emissions are primarily from fossil fuels burned for heat, the use of products like refrigerants that contain GHGs, and the handling of waste and wastewater.
- **Agriculture –** GHG emissions from this sector comes from livestock such as cows, agricultural soils, and rice production.

Table 19 further breaks down GHG emissions by major source category within each major GHG and shows GHG trends from 1990 to 2020.

The gross emissions totals presented in this report for the United States exclude emissions and removals from Land Use, Land-Use Change, and Forestry (LULUCF), whereas the net emissions totals presented include emissions and removals from LULUCF (see Table 19).

Table 19. Trends in U.S. GHG Emissions and Sinks

Gas/Source (MMT CO_2e)	1990	2005	2016	2017	2018	2019	2020
CO_2	5,122.5	6,137.60	5,251.80	5,211.00	5,376.70	5,259.10	4,715.70
Fossil fuel combustion	4,731.2	5,752.0	4,909.6	4,853.3	4,989.3	4,852.3	4,342.7
Transportation	1,468.9	1,858.6	1,757.6	1,780.0	1,812.8	1,813.8	1,572.0
Electric power	1,820.00	2,400.1	1,808.9	1,732.0	1,752.9	1,606.1	1,439.0
Industrial	853.7	851.5	792.7	790.4	814.1	816.1	766.3
Residential	338.6	358.9	292.8	293.4	338.2	341.4	315.8
Commercial	228.3	227.1	231.5	232.0	245.8	250.7	226.8
U.S. territories	21.7	55.9	26.0	25.5	25.5	24.3	22.7
Non-energy use of fuels	112.2	128.9	99.5	112.6	128.9	126.8	121.0
Iron and steel production and metallurgical coke production	104.7	70.1	43.6	40.6	42.6	41.3	37.7
Cement production	33.5	46.2	39.4	40.3	39.0	40.9	40.7
Petroleum systems	9.6	12.0	21.9	25.0	37.3	46.7	30.2
Natural gas systems	31.9	24.9	29.8	31.1	32.4	38.7	35.4
Petrochemical production	21.6	27.4	28.1	28.9	29.3	30.7	30.0
Ammonia production	13.0	9.2	10.2	11.1	12.2	12.3	12.7
Lime production	11.7	14.6	12.6	12.9	13.1	12.1	11.3
Incineration of waste	12.9	13.3	14.4	13.2	13.3	12.9	13.1
Other process uses of carbonates	6.2	7.5	10.8	9.9	7.4	9.8	9.8
Urea fertilization	2.4	3.5	4.7	4.9	5.0	5.1	5.3

Gas/Source (MMT CO_2e)	1990	2005	2016	2017	2018	2019	2020
CO_2 consumption	1.5	1.4	4.6	4.6	4.1	4.9	5.0
Urea consumption for non-agricultural purposes	3.8	3.7	5.3	5.2	6.0	6.0	6.0
Liming	4.7	4.3	3.1	3.1	2.2	2.4	2.4
Coal Mining	4.6	4.2	2.8	3.1	3.1	3.0	2.2
Ferroalloy production	2.2	1.4	1.8	2.0	2.1	1.6	1.4
Soda ash production	1.4	1.7	1.7	1.8	1.7	1.8	1.5
Titanium dioxide production	1.2	1.8	1.7	1.7	1.5	1.5	1.3
Aluminum production	6.8	4.1	1.3	1.2	1.5	1.9	1.7
Glass production	2.3	2.4	2.1	2.0	2.0	1.9	1.9
Zinc production	0.6	1.0	0.8	0.9	1.0	1.0	1.0
Phosphoric acid production	1.5	1.3	1.0	1.0	0.9	0.9	0.9
Lead production	0.5	0.6	0.5	0.5	0.5	0.5	0.5
Carbide production and consumption	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Abandoned oil and gas wells	+	+	+	+	+	+	+
Magnesium production and processing	0.1	+	+	+	+	+	+
Wood biomass, ethanol, and biodiesel consumption(1)	219.4	244.6	316.6	312.3	319.6	316.2	291.6
International bunker fuels(2)	103.5	115.4	116.6	120.1	122.1	116.1	69.6
CH_4(3)	776.9	693.9	642.4	648.4	655.9	659.7	650.4
Enteric fermentation	164.7	174.9	172.2	175.8	178	178.6	175.2
Natural gas systems	186.9	165.3	147.3	148.7	152.5	157.6	164.9
Landfills	176.6	127.2	108	109.4	112.1	114.5	109.3
Manure management	37.1	56	59.6	59.9	61.7	62.4	59.6
Coal mining	96.5	64.8	53.8	54.8	52.7	47.4	41.2
Petroleum systems	48.9	42.4	39.2	39.3	37.3	39.1	40.2
Wastewater treatment	20.2	19.9	18.7	18.5	18.4	18.4	18.3
Rice cultivation	16	15.9	15.8	14.9	15.6	15.1	15.7

Gas/Source (MMT CO_2e)	1990	2005	2016	2017	2018	2019	2020
Stationary combustion	8.6	7.7	7.9	7.6	8.5	8.7	7.9
Abandoned oil and gas wells	6.8	7.2	7.4	7.2	7.3	6.6	6.9
Abandoned underground coal mines	7.2	6.3	6.7	6.4	6.2	5.9	5.8
Mobile combustion	6.4	3.7	2.5	2.5	2.4	2.4	2.3
Composting	0.4	2	2.3	2.4	2.3	2.3	2.2
Field burning of agricultural residues	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Petrochemical production	0.2	0.1	0.2	0.3	0.3	0.3	0.3
Anaerobic digestion at biogas facilities	+	+	0.2	0.2	0.2	0.2	0.2
Ferroalloy production	+	+	+	+	+	+	+
Carbide production and consumption	+	+	+	+	+	+	+
Iron and steel production and metallurgical coke production	+	+	+	+	+	+	+
Incineration of waste	+	+	+	+	+	+	+
International bunker fuels (2)	0.2	0.1	0.1	0.1	0.1	0.1	0.1
N_2O (3)	450.5	453.3	449.2	444.6	457.7	456.8	426.1
Agricultural soil management	316.0	313.8	330.8	328.3	338.9	345.3	316.2
Stationary combustion	25.1	34.4	30.0	28.4	28.2	24.9	23.2
Manure management	13.9	16.3	18.4	19.0	19.3	19.5	19.7
Mobile combustion	44.6	41.4	21.1	20.1	19.2	20.0	17.4
Adipic acid production	15.2	7.1	7.1	7.5	10.5	5.3	8.3
Nitric acid production	12.1	11.3	10.1	9.3	9.6	10.0	9.3
Wastewater treatment	16.6	20.3	22.8	23.2	23.5	23.4	23.5
N_2O from product uses	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Composting	0.3	1.7	2.0	2.2	2.0	2.0	2.0
Caprolactam, glyoxal, and glyoxylic acid production	1.7	2.1	1.7	1.5	1.4	1.4	1.2

Gas/Source (MMT CO_2e)	1990	2005	2016	2017	2018	2019	2020
Incineration of waste	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Electronics industry	+	0.1	0.2	0.3	0.3	0.2	0.3
Field burning of agricultural residues	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Petroleum systems	+	+	+	+	+	+	+
Natural gas systems	+	+	+	+	+	+	+
International bunker fuels (2)	0.9	1.0	1.0	1.1	1.1	1.0	0.6
HFCs	46.5	127.4	168.3	171.1	171.0	175.9	178.8
Substitution of O_3-depleting substances (4)	0.2	107.2	165.1	165.5	167.3	171.8	176.2
HCFC-22 production	46.1	20.0	2.8	5.2	3.3	3.7	2.1
Electronics industry	0.2	0.2	0.3	0.4	0.4	0.4	0.4
Magnesium production and processing	NO	NO	0.1	0.1	0.1	0.1	0.1
PFCs	24.3	6.7	4.4	4.2	4.8	4.6	4.4
Electronics industry	2.8	3.3	3.0	3.0	3.1	2.8	2.7
Aluminum production	21.5	3.4	1.4	1.1	1.6	1.8	1.7
Substitution of O_3-depleting substances	NO	+	+	+	0.1	0.1	0.1
SF_6	28.8	11.8	6	5.9	5.7	5.9	5.4
Electrical transmission and distribution	23.2	8.3	4.1	4.2	3.8	4.2	3.8
Magnesium production and processing	5.2	2.7	1.1	1.0	1.0	0.9	0.9
Electronics industry	0.5	0.5	0.8	0.7	0.8	0.8	0.7
NF_3	+	0.5	0.6	0.6	0.6	0.6	0.6
Electronics industry	+	0.5	0.6	0.6	0.6	0.6	0.6
Unspecified mix of HFCs, PFCs, SF_6, and NF_3	+	+	+	+	+	+	
Electronics industry	NO	+	+	+	NO	+	
Total emissions	6,453.5	7,434.8	6,537.9	6,501.0	6,687.5	6,571.7	5,981.4
LULUCF emissions(3)	31.4	41.3	35.4	45.5	39.8	30.3	53.2
LULUCF CH_4 emissions	27.2	30.9	28.3	34.0	30.7	25.5	38.1
LULUCF N_2O emissions	4.2	10.5	7.1	11.5	9.1	4.8	15.2

Gas/Source (MMT CO_2e)	1990	2005	2016	2017	2018	2019	2020
LULUCF carbon stock change[(5)]	892.0	831.1	862.0	826.7	809.0	760.8	812.2
LULUCF sector net total[(6)]	860.6	789.8	826.6	781.2	769.3	730.5	758.9
Net Emissions (Sources and Sinks)	5,592.8	6,645.0	5,711.2	5,719.8	5,918.2	5,841.2	5,222.4

Source: Data obtained from Table 2-1 of US Inventory of Greenhouse Gases and Sinks (EPA 2022p).

Notes: Total emissions presented without LULUCF. Net emissions presented with LULUCF. Totals may not sum due to independent rounding. Parentheses indicate negative values or sequestration.

+ Does not exceed 0.05 MMT CO_2e.

NO = not occurring

(1) Emissions from wood biomass, ethanol, and biodiesel consumption are not included specifically in summing energy sector totals. Net carbon fluxes from changes in biogenic carbon reservoirs are accounted for in the estimates for LULUCF.

(2) Emissions from international bunker fuels are not included in totals.

(3) LULUCF emissions of CH_4 and N_2O are reported separately from gross emissions totals. LULUCF emissions include the CH_4 and N_2O emissions reported for peatlands remaining peatlands, forest fires, drained organic soils, grassland fires, and coastal wetlands remaining coastal wetlands; CH_4 emissions from land converted to coastal wetlands, flooded land remaining flooded land, and land converted to flooded land; and N_2O emissions from forest soils and settlement soils.

(4) Small amounts of PFC emissions also result from this source.

(5) LULUCF carbon stock change is the net carbon stock change from the following categories: forest land remaining forest land, land converted to forest land, cropland remaining cropland, land converted to cropland, grassland remaining grassland, land converted to grassland, wetlands remaining wetlands, land converted to wetlands, settlements remaining settlements, and land converted to settlements.

(6) The LULUCF sector net total is the net sum of all LULUCF CH_4 and N_2O emissions to the atmosphere plus net carbon stock changes.

Within the CO_2 pollutant category there are 28 source categories reported in the inventory; the CH_4 pollutant category has 20 source categories, and the N_2O pollutant category has 16 source categories reported. Other pollutant categories reported in the annual inventory report include HFCs, PFCs, SF_6 and NF_3 (see Table 19).

10.6 NATURAL GAS SYSTEMS AND PETROLEUM SYSTEMS

Within the fossil fuel combustion sector, in 2020, the contribution by fuel type shows that petroleum represents 43.7% of the fuel type, natural gas 37.1%, and coal 19.2% (Figure 19).

The EPA's national GHG emissions inventory describes "Natural Gas Systems" and "Petroleum Systems" as two of the major sources of U.S. GHG emissions. The inventory identifies the major contributions of natural gas and petroleum systems as total CO_2 and CH_4 emissions. Natural gas and petroleum systems do not produce noteworthy amounts of any other GHGs.

Total GHG emissions (CH_4, CO_2, and N_2O) from natural gas systems in 2020 were 200.3 MMT CO_2e, a decrease of 12% from 1990, primarily due to decreases in CH_4 emissions, and a decrease of 5% from 2019, primarily due to decreases in CH_4 emissions. Of the overall GHG emissions (200.3 MMT CO_2e), 82% are CH_4 emissions as expressed as CO_2e (164.9 MMT CO_2e), 18% are CO_2 emissions (35.4 MMT), and less than 0.01% are N_2O emissions as expressed as CO_2e (0.01 MMT CO_2e).

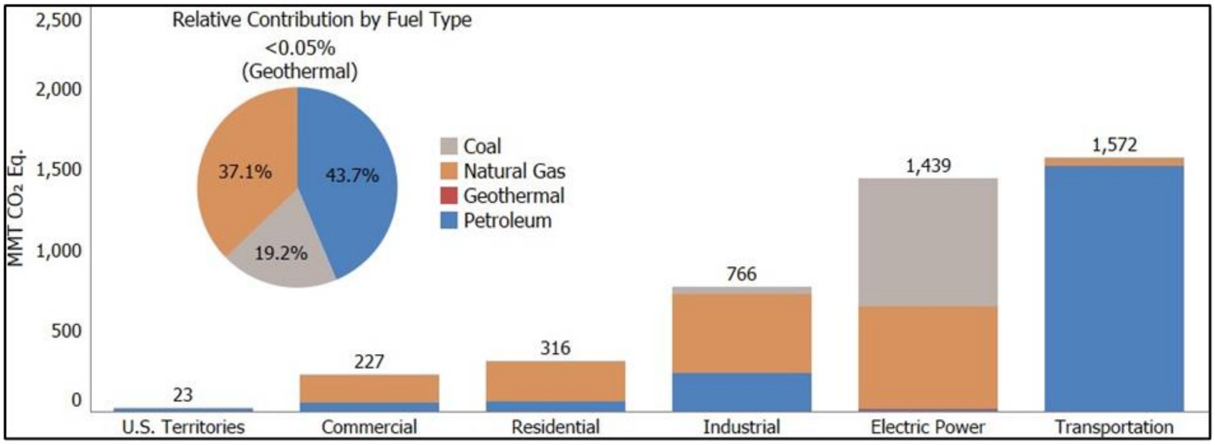


Figure 19. 2020 CO_2 emissions from fossil fuel combustion by sector and fuel type.

Within the category of "Natural Gas Systems," the EPA identifies emissions occurring during distinct stages of operation, including field production, processing, transmission and storage, and distribution. "Petroleum Systems" sub-activities include production field operations, crude oil transportation and crude oil refining. Within the Natural Gas Systems and Petroleum Systems the BLM has authority to regulate those field production operations that are related to oil and gas measurement and prevention of waste (via leaks, spills and unauthorized flaring and venting).

Total GHG emissions (CH_4, CO_2, and N_2O) from petroleum systems in 2020 were 70.4 MMT CO_2e, an increase of 18% from 1990, primarily due to increases in CO_2 emissions. Since 2019, total emissions from petroleum systems increased by 19%. Of the overall GHG emissions (70.4 MMT CO_2e), 30.2 MMT are CO_2 emissions, 40.2 MMT CO_2e are from CH_4 emissions, and 0.05 MMT CO_2e (0.24 kt N2O), are from N_2O emissions from petroleum systems in 2020. U.S. oil production increased by 2% from 2019 to 2020.

CH_4 emissions from petroleum systems are primarily associated with onshore and offshore crude oil production, transportation, and refining operations. During these activities, CH_4 is released to the atmosphere as emissions from leaks, venting (including emissions from operational upsets), and flaring. CO_2 emissions from petroleum systems are primarily associated with crude oil production and refining operations. Note that in the EPA's reported data, CO_2 in the petroleum systems emissions exclude all combustion emissions (e.g., engine combustion) except for flaring CO_2 emissions. All combustion CO_2 emissions (except for flaring) are accounted for in the fossil fuel combustion category. Emissions of N_2O from petroleum systems are primarily associated with flaring.

For natural gas, extraction accounts for 55%, processing accounts for 27%, and transmission accounts for 18% of life cycle CO_2e emissions (U.S. Department of Energy 2011). For oil, drilling and development is responsible for 8% of the total life cycle CO_2e emissions, whereas transportation of the petroleum to refineries represents about 10% of the emissions, and final consumption as transportation fuel represents fully 80% of emissions (U.S. Department of Energy 2008).

Table 20 displays GHG emissions (CO_2, CH_4~~,~~ and N_2O) related to natural gas systems, petroleum systems, and coal mining. In Table 20, CO_2 emissions listed represent CO_2 emissions which are not otherwise captured in the "fossil fuel combustion" category. The natural gas and petroleum subsectors are the stages of production outlined in the table below and the subsectors that BLM regulates for onshore operations on federal mineral estate are highlighted in gray.

Table 20. 2020 GHG Emissions for Oil and Gas Subsectors and Coal Mining

Sector	Subsector	2020 GHG Emissions (MMT CO_2e)				% of U.S. Total GHGs
		CO_2	CH_4[(1)]	N_2O	Total GHGs	
Natural gas systems	Total	35.4	164.9	0.01	200.3	3.35%
	Exploration[(2)]	0.1	0.2	0.0001	0.3	0.005%
	Production field operations	7.7	86.4	0.004	94.1	1.57%
	Onshore production	NE	47.6	NE	NE	NE
	Offshore production	NE	1.0	NE	NE	NE
	Gathering and boosting[(3)]	NE	37.5	NE	NE	NE
	Processing	25.5	12.4	0.005	37.8	0.63%
	Transmission and storage	2.0	40.6	0.001	42.7	0.71%
	Distribution	**	13.9	Not occurring	13.9	0.23%
Petroleum systems	Total	30.2	40.2	0.04	70.4	1.18%
	Exploration[(2)]	0.9	0.3	0.0004	1.2	0.02%
	Production field operations	25.0	38.9	0.02	63.9	1.07%
	Crude oil transportation	**	0.2	NE	0.2	0.003%
	Crude refining	4.3	0.8	0.013	5.1	0.09%
Coal mining	--	*+	41.2	*	41.2	0.69%
U.S. total		4,715.7	650.4	426.1	5,981.4***	100%

Source: EPA (2022p)

* Indicates values less than 0.1 teragrams (Tg) CO_2e.

** Indicates values that do not exceed 0.05 TgCO_2e.

*** Indicates that the total U.S. GHG emissions value includes U.S. emissions of three additional minor classes of GHGs not listed here.

NE = Not estimated

+ Includes data from abandoned coal mines.

Data obtained from Table 2-1 of 2020 Inventory Data (EPA 2022p).

(1) These values represent CH_4 emitted to the atmosphere. CH_4 that is captured, flared, or otherwise controlled (and not emitted to the atmosphere) has been calculated and removed from emission totals.

(2) Exploration includes well drilling, testing, and completions.

(3) Gathering and boosting includes gathering and boosting station routine vented and leak sources, gathering pipeline leaks and blowdowns, and gathering and boosting station episodic events.

In summary, CO_2 is produced during the burning of fossil fuels to run internal combustion engines that may be used in drilling, transportation, pumping, and compression. CO_2 may be a significant component of natural gas, especially coalbed CH_4, and is vented during field operations or processing. CO_2 is also used in enhanced oil production processes and may be released or escape to the atmosphere during those processes. CH_4 is the primary component of natural gas and is released to the atmosphere during both oil and gas production either intentionally during production when it cannot be captured, or accidentally through leaks and fugitive emissions.

10.6.1 TRENDS

Globally, emissions of CO_2 from flaring of unused gas during oil production decreased by about one-quarter between 2003 and 2011; however, flaring emissions for the United States are on the rise and increased by 50% in 2011 because of the significant increase in fracking for shale oil production and the flaring of co-produced natural gas (Olivier et al. 2012). CO_2 emissions from natural gas and petroleum systems increased by 27% from 1990 to 2017, due to increases in flaring emissions.

10.7 NATIONAL GREENHOUSE GAS EMISSIONS GREENHOUSE GAS REPORTING PROGRAM (FLIGHT)

The Greenhouse Gas Reporting Program (GHGRP) is codified by regulation (40 C.F.R. 98) and requires reporting of GHG data and other relevant information from large GHG emission sources, fuel and industrial gas suppliers, and CO_2 injection sites in the United States. In total, 41 categories are covered by the program. Facilities are generally required to submit annual reports under 40 C.F.R. 98 if:

- GHG emissions from covered sources exceed 25,000 metric tons CO_2e per year.
- Supply of certain products would result in over 25,000 metric tons CO_2e of GHG emissions if those products were released, combusted, or oxidized.
- The facility receives 25,000 metric tons or more of CO_2 for underground injection.

The reported data are usually made available to the public in October of each year. It should be noted that the GHGRP does not represent total U.S. GHG emissions but provides facility level data for large sources of direct emissions, thus representing the majority of U.S. GHG emissions. The GHGRP data collected from direct emitters represent about half of all U.S. emissions. When including GHG information reported to the GHGRP by suppliers, emissions coverage reaches approximately 85% to 90%. The *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020* contains information on all GHG emissions sources and sinks in the United States. For more information, please visit https://www.epa.gov/ghgreporting.

10.7.1 COMPRESSOR ENGINES AND STATIONS (MIDSTREAM) REPORTED GREENHOUSE GAS EMISSIONS

Compressor engines link the natural gas pipeline infrastructure that transports natural gas from its source to points of consumption. Table 21 shows the GHG emissions from transmission compressor stations and gas plants for each state where BLM NMSO has mineral estate, from the 2020 Greenhouse Gas Facility Level Information on Greenhouse Gases Tool (FLIGHT). Some gas plants and compressor stations' emissions may not be reported to FLIGHT because emissions from the plant or station do not exceed EPA's GHG reporting threshold. Additionally, there are also gathering compression stations that are not considered "point sources" under the Mandatory Reporting Rule, which are reported under the oil and gas gathering and boosting industry segment.

Table 21. 2020 Midstream GHG from Gas Plants and Compressor Stations

State	Number of Reporting Transmission Compressor Stations	Total GHG Emissions from Reporting Compressor Stations (MMT CO_2e)	% U.S. Total Reported Compressor Station GHG Emissions	Number of Reporting Gas Plants	Total GHG Emissions from Reporting Gas Plants (MMT CO_2e)	% U.S. Total Reported Gas Plant GHG Emissions
New Mexico	17	0.60	2.00	25	4.2	7.12
Texas	96	4.3	14.33	214	25	43.37
Oklahoma	20	0.63	2.10	50	2.5	4.24
Kansas	22	0.85	2.83	5	0.73	1.24

Source: EPA (2021o)

Emissions from oil and gas "point sources," including natural gas processing, transmission/compression, transmission pipelines, and storage and distribution, in the United States totaled 106 MMT CO_2e in 2020, which was about 4.07% of total U.S. GHG emissions reported to EPA in 2020 (EPA 2022q). Emissions from the onshore oil and gas gathering and boosting segment (which includes compressor stations, meter stations, gathering pipelines, and other miscellaneous midstream oil and gas support facilities) totaled 90 MMT CO_2e in 2020 (EPA 2022q).

10.7.2 REFINERIES (MIDSTREAM) REPORTED GREENHOUSE GAS EMISSIONS

Crude oil produced throughout the BLM NMSO area is transported by pipeline and/or tanker truck to refineries where the oil is processed into various types of fuel. Table 22 shows the GHG emissions from refineries in each BLM-NM state.

Table 22. 2020 Greenhouse Gas Emissions from Refineries

State	Number of Reporting Refineries	Total GHG Emissions from Reporting Refineries (MMT CO_2e)	% U.S. Total Reported Refinery GHG Emissions
New Mexico	3	1.0	0.0003%
Texas	30	52.0	0.02%
Oklahoma	5	4.3	0.002%
Kansas	3	2.8	0.001%

Source: EPA (2022q)

There are three refineries in New Mexico: one in Jamestown (Gallup Refinery), one in Artesia, and one in Lovington. Kansas has three refineries, Oklahoma has five, and Texas has 30. Transportation and processing of crude oil and petroleum products result in emissions of various HAPs, criteria pollutants, and GHGs. In 2020, GHG emissions from refineries (total of 140 reporting) accounted for 161 MMT CO_2e emitted, which is 6.11% of the 2020 total GHG emissions reported to EPA (EPA 2022q).

10.7.3 STATE GREENHOUSE GASES

The predicted GHG emissions are compared with the baseline statewide GHG emissions as reported in the New Mexico Greenhouse Gas Emissions Inventory and Forecast (Center for the New Energy Economy [CNEE] 2020). The Inventory of New Mexico Greenhouse Gas Emissions Inventory and Forecast lists total statewide gross GHG emissions in 2018 as 113.6 MMT CO_2e. For 2018, NMED reported that oil and gas (fugitive emissions and fuel combustion) are the primary contributors to the state's GHG emissions (53%), along with transportation (14%) and electricity generation (11%) (CNEE 2020).

10.7.4 OTHER MAJOR INDUSTRIES GENERATING GREENHOUSE GAS EMISSIONS

Potash mining is another major industry in the CFO area. There are two mining companies operating four potash processing plants in the CFO area. Potash production produces emissions of various HAPs, criteria pollutants, and GHGs. In 2015, potash mines in southeastern New Mexico emitted 97,140 metric tons of CO_2e cumulatively. This is 0.002% of total U.S. GHG emissions (EPA 2022p). In 2016, CO_2e emissions decreased significantly as some facilities discontinued reporting GHG emissions for valid reasons: operations had ceased, operations were changed such that a process or operation no longer meets the "Definition of Source Category," the entire facility or supplier was merged into another facility or supplier that already reports to the GHGRP, the facility reported emissions or quantity of GHG supplied of less than 15,000 metric tons CO_2e for 3 consecutive years, or the facility reported emissions or quantity of GHG supplied of less than 25,000 metric tons CO_2e for 5 consecutive years . Thus, in 2019 the emissions from Intrepid Potash reported only 8,109 metric tons CO_2e, which is 0.0001% of total U.S. GHG emissions. As of 2020, zero metric tons of CO_2e were reported.

Coal mining is another major industry in San Juan County. Westmoreland purchased the San Juan Mine from BHP Billiton and began ownership 2016. BHP Billiton also transferred ownership of the Navajo Mine, located near Fruitland, New Mexico, to the Navajo Transitional Energy Company at the end of 2016. The San Juan Mine provides coal to the San Juan Generating Station, and the Navajo Mine provides coal to the Four Corners Power Plant. Coal production produces emissions of various HAPs, criteria pollutants, and GHGs. In 2020, the San Juan Mine reported 0.27 MMT CO_2e, while data for the Navajo Mine were not available. In 2020, coal mining in the United States contributed 41.2 MMT CO_2e from CH_4, which is 6.3% of total U.S. CH_4 emissions and 0.69% of total U.S. GHG emissions (see Table 20).

11 CUMULATIVE GREENHOUSE GAS EMISSIONS

11.1 GOLDER ASSOCIATES REPORT (2017), GREENHOUSE GAS EMISSIONS FROM THE COAL, OIL, AND GAS LEASING PROGRAM WITHIN THE STATES OF NEW MEXICO, TEXAS, KANSAS, AND OKLAHOMA

In 2017, the BLM commissioned a climate change report with an energy focus. The report calculates GHG emissions associated with production and consumption activities related to coal, oil, natural gas, and natural gas liquids. The baseline year is 2014 and forecasts production/consumption GHG emissions for 2030 for federal and non-federal lands on a national level and for 13 energy-producing states, not limited to New Mexico, Oklahoma, Texas, and Kansas. Inputs for the report were developed using publicly available online information from such sources as the EIA, the EPA's *Greenhouse Gas Inventory Report: 1990–2014* (EPA 2016), Office of Natural Resources Revenue (ONRR), U.S. Extractive Industries Transparency Initiative, BLM oil and gas statistics, and others as applicable to each state. More information on the methodology and assumptions, as well as other data sources for all 13 states, is in the *Greenhouse Gas and Climate Change Report, 2017* (Golder Associates 2017), which is herein incorporated by reference.

The BLM approximated national GHG emissions (CO_2e) from energy production for the baseline year 2014 and future year 2030. Growth factors are applied as compound growth, where the exponents of each factor are raised to represent the number of years ahead of the baseline year of 2014 (Golder Associates 2017). Baseline growth or decline factors were developed based on data taken from Tables A1 and B1 of the EIA's 2016 AEO. Two scenarios were developed: normal growth and high growth. Table 23 shows the 2014 baseline CO_2e emissions from fossil fuel production as well as future projections of 2030 in the United States across federal and non-federal sectors. All projections rely on EIA's 2016 AEO growth factors. GHG emissions for future projections present only the high growth scenario; the normal growth scenario can be found in the Golder Associates report (Golder Associates 2017).

The BLM uses projections of the total federal and non-federal oil and gas emissions from Golder Associates (2017) to estimate expected annual future GHG emissions from energy production and consumption activity within a subnational region, including New Mexico, Oklahoma, Kansas, and Texas, which are within the administrative jurisdiction of the BLM NMSO. Assumptions of the analysis are discussed in Golder Associates (2017). The following are key assumptions:

- State-specific oil consumption is equal to state total production minus export and reserves for the state based on national averages.
- National averages for sector breakdown percentages (power, industrial, etc.) for oil, natural gas, and natural gas liquids consumptions were applied to state-specific data.
- The value of production and consumption on non-federal land is equal to the difference of the total state or national value minus the federal land value.

At the state level, production does not necessarily translate to 100% consumption of the fossil fuel but is representative of future energy consumption and production to show GHG emissions. New Mexico is an important supplier of electricity to the western United States. The state's power plants have historically produced more electricity than is consumed in the state, and have exported significant amounts of electricity to Arizona, California, and other western states. In 2000, for instance, New Mexico power plants produced 36% more electricity than needed for in-state use. The New Mexico electricity sector is also dominated by coal, which accounts for nearly 90% of all electricity generated in recent years. Coal-fired power plants produce as much as twice the CO_2 emissions per kilowatt-hour of electricity as natural gas–fired power plants. As a result of these factors, New Mexico power plants are the largest source of GHG emissions in the state (NMED 2010).

The development projected in the RFDs for each BLM field office under NMSO jurisdiction (such as the 2016 RFD for the PDO) is considered in these data (see Engler et al. 2012; Engler and Cather 2014). Current and future oil and gas lease sales are part of each RFD. Because the BLM NMSO administers lease sales within its jurisdictional area, this section provides a discussion of reasonably foreseeable production and consumption for these states and discloses the magnitude of GHG emissions likely to result from BLM NMSO lease sale activities on an annual basis. This information is further contextualized by comparing the relative magnitude of these emission with projected national and global annual GHG emission rates.

Table 23. Fossil Fuel Production and Future Year Scenarios Using AEO 2016 Outlook

2014 Baseline Fossil Fuel Production in the U.S.							
	Oil Barrels (bbl)	**CO_2e (MMT)**	**Gas (MMcf)**	**CO_2e (MMT)**	**Coal (short tons)**	**CO_2e (MMT)**	**Total CO_2e (MMT) All Fossil Fuels**
U.S.	3,196,889,000	1,375	25,889,605	1,417	1,000,048,758	1,900.09	4,691.39
BLM national	155,424,817	67	3,399,894	186	409,345,817	777.76	1,030.63
Non-BLM national	3,041,464,183	1,308	22,489,711	1,231	590,702,941.00	1,122.34	3,660.76
2030 Future Fossil Fuel Production in the U.S. Future, High Growth Scenarios							
	Oil Barrels (bbl)	**CO_2e (MMT)**	**Gas (MMcf)**	**CO_2e (MMT)**	**Coal (short tons)**	**CO_2e (MMT)**	**Total CO_2e (MMT) All Fossil Fuels**
U.S. high growth	3,907,285,000	1,680	37,628,912	2,059	665,345,945	1,264.16	5,003.27
BLM national high growth	191,073,000	82	4,972,475	272	269,398,309	511.86	866.10
Non-BLM national high growth	3,716,212,000	1,598	32,656,437	1,787	395,947,636	752.30	4,137.17

Source: Golder Associates (2017)

Although quantified estimates of potential GHG emissions associated with reasonably foreseeable energy development are presented, there is uncertainty with regard to eventual production volumes and variability in flaring, construction, transportation, etc. A rough estimate was possible using publicly available information and estimates from the RFD. Also, there is uncertainty with regard to the net effects of reasonably foreseeable energy development on climate; that is, while BLM actions may contribute to climate change, the specific effects of those actions on global climate are speculative given the current state of the science. Inconsistencies in the results of scientific models designed to predict climate change on regional or local scales limit the ability to quantify potential future effects of decisions made at this level and to determine the significance of any discrete amount of GHG emissions.

Nonetheless, the projected emission estimates for Texas, New Mexico, Kansas, and Oklahoma contribute to global GHG emissions. This, in turn, affects the concentrations of GHG in the atmosphere, which influences climate change. The relative magnitude of the contribution of the BLM NMSO GHG emissions from oil and gas, as well as coal and natural gas liquids, leasing activities in New Mexico, Texas, Oklahoma, and Kansas will vary based on trends in national and global GHG emissions. However, for context, based on current global and national emission trends from the most recent available data, it is estimated that the 2014 baseline emissions for the BLM NMSO federal contribution from coal, oil, gas, and natural gas liquids leasing represent approximately 1.54% of national GHG emissions and 0.21% of global GHG emissions. BLM NMSO oil and gas leasing GHG emissions would be estimated to represent around 1.11% of national GHG emissions and 0.15% of global GHG emissions based on the 2014 baseline emissions.

11.1.1 NEW MEXICO COAL, OIL, AND GAS GREENHOUSE GAS EMISSIONS

The BLM's reasonably foreseeable coal, oil, and gas production and consumption GHG emissions from federal activities in New Mexico are 99.35 MMT CO_2e for the 2030 high scenario (Table 24). These represent increases of 7.2%, respectively, from the 2014 baseline coal, oil, and gas GHG emissions (92.75 MMT of CO_2e). New Mexico federal coal, oil, and gas GHG emissions of 99.35 MMT CO_2e/year (2030 high scenario) would represent 52% of state 2030 high reasonably foreseeable coal, oil, and gas GHG emissions (see Table 24).

Table 24. Reasonably Foreseeable Coal, Oil and Gas Production, and GHG Consumption Emissions in New Mexico, Oklahoma, Kansas, and Texas

GHG Emissions (MMT CO_2e)					
Category	**New Mexico**	**Oklahoma**	**Kansas**	**Texas**	**NM, OK, KS, TX**
2030 high scenario					
Federal coal	10.14	0.91	0	0	11.05
Federal oil	25.60	0.33	0.08	0.06	26.07
Federal gas	57.44	1.11	0.34	2.78	61.67
Federal natural gas liquids	6.17	0.09	0.05	0.04	6.35
Total federal	**99.35**	**2.44**	**0.47**	**2.88**	**105.14**
Federal + non-federal coal	31.52	1.37	0.1	71.12	104.11
Federal + non-federal oil	55.51	56.95	22.19	520.20	654.85

GHG Emissions (MMT CO_2e)					
Category	**New Mexico**	**Oklahoma**	**Kansas**	**Texas**	**NM, OK, KS, TX**
Federal + non-federal gas	96.45	176.21	21.02	804.05	1,097.72
Federal + non-federal natural gas liquids	12.25	20.27	3.17	84.88	120.57
Total federal and non-federal	**195.73**	**254.8**	**46.47**	**1,480.25**	**1,977.25**

Source: Golder Associates (2017).

Note: Totals may not sum exactly due to rounding.

11.1.2 OKLAHOMA COAL, OIL, AND GAS GREENHOUSE GAS EMISSIONS

BLM's reasonably foreseeable coal, oil, and gas production and consumption GHG emissions from federal activities in Oklahoma are 2.44 MMT of CO_2e for the 2030 high scenario (see Table 24). This is a decrease of 9.8% from the 2014 baseline coal, oil, and gas GHG emissions (2.68 MMT of CO_2e). Oklahoma federal coal, oil, and gas GHG emissions of 2.44 MMT CO_2e/year (2030 high scenario) would represent 0.96% of state 2030 high reasonably foreseeable GHG emissions from coal, oil, and gas activities (see Table 24).

11.1.3 KANSAS COAL, OIL, AND GAS GREENHOUSE GAS EMISSIONS

BLM's reasonably foreseeable coal, oil, and gas production and consumption GHG emissions from federal activities in Kansas are 0.47 MMT CO_2e for the 2030 high scenario (see Table 24). These values represent increases of 14.9%, compared with the 2014 baseline coal, oil, and gas GHG emissions (0.40 MMT CO_2e). Kansas federal coal, oil, and gas GHG emissions of 0.47 (2030 High scenario) MMT CO_2e/year would represent 1.01% of state 2030 high reasonably foreseeable GHG emissions from coal, oil, and gas activities (see Table 24).

11.1.4 TEXAS COAL, OIL, AND GAS GREENHOUSE GAS EMISSIONS

BLM's reasonably foreseeable coal, oil, and gas production and consumption GHG emissions from federal activities in Texas are 2.88 MMT of CO_2e for the 2030 high scenario (see Table 24). This represents an increase of 16.7%, compared with the 2014 baseline coal, oil, and gas GHG emissions (2.40 MMT of CO_2e). Texas federal coal, oil, and gas GHG emissions of 2.88 (2030 high scenario) MMT CO_2e/year would represent 0.19% of state 2030 high reasonably foreseeable GHG emissions from coal, oil, and gas activities (see Table 24).

11.2 2021 BLM SPECIALIST REPORT ON ANNUAL GREENHOUSE GAS EMISSIONS AND CLIMATE TRENDS FROM COAL, OIL, AND GAS EXPLORATION AND DEVELOPMENT ON THE FEDERAL MINERAL ESTATE

The *2021 BLM Specialist Report on Annual Greenhouse Gas Emissions and Climate Trends* (https://www.blm.gov/content/ghg/2021/) presents the estimated emissions of GHGs attributable to fossil fuels produced on land and mineral estate managed by the BLM. The report is focused on estimating GHG emissions from coal, oil, and gas development that is occurring, and is projected to occur, on the federal onshore mineral estate. The report includes a summary of emissions estimates from reasonably foreseeable federal fossil fuel development and production over the next 12 months, as well as longer-term assessments of potential federal fossil fuel GHG emissions and the anticipated climate change impacts resulting from the cumulative global GHG burden. The report can provide context by disclosing cumulative impacts of GHG emissions from fossil fuel energy leasing and development authorizations on the federal onshore mineral estate relative to several emission scopes and base years.

Emissions estimates in the 2021 BLM Specialist Report were developed using fiscal year 2021 data for both direct and indirect emissions. Direct emissions can result from authorized activities such as drilling or venting, while indirect emissions occur as a consequence of the authorized action and can include activities such as the processing, transportation, and any end-use combustion of the fossil fuel mineral products. The emission estimates are expressed as megatonnes (Mt) of CO_2e on either a rate or absolute basis.

Report year emissions and projected emissions from BLM crude oil, gas, and coal leasing authorizations and permitting actions are based on ONRR records of actual oil, gas, and coal production.

Table 25 shows a summary of the ONRR production data from states that reported federal oil, gas, and coal production during the 5 years between 2016 and 2021, highlighting the years 2017 and 2021. The table also shows total U.S. oil, gas, and coal production (federal and non-federal) to illustrate the percentage of federal oil relative to the U.S. total (% U.S. total) and the percentage of federal oil, gas and coal that comes from the various federal oil producing states (% federal). The U.S. total data includes all oil and gas produced from both onshore and offshore sources. The percent total calculations are based on the 5-year average data column. The table also shows the estimated 2021 GHG emissions for the United States (federal and non-federal) and by mineral boundary including New Mexico, Oklahoma, Kansas, and Texas.

Table 25. ONRR Production Data - Federal Oil, Gas, and Coal Production and 2021 Emissions

State	Mineral	2017	2021	5-year Average	% Total	% Federal	2021 Total CO_2e (Mt)
U.S. Total	**Coal (tons)**	**774,609,357**	**578,061,000**	**670,116,214**	**100%**	**NA**	**1,181.22**
Federal Total	**Coal (tons)**	**333,532,290**	**252,569,978**	**288,801,359**	**43.10%**	**100%**	**448.30**
Kansas		0	0	0	0%	0%	0
New Mexico		6,289,723	736,759	2,999,292	0.45%	1.04%	1.71
Oklahoma		464,551	0	210,267	0.03%	0.07%	n/a
Texas		0	0	0	0%	0%	0
	Total Coal CO_2 Emissions - Kansas, New Mexico, Oklahoma, Texas						450.01
U.S. Total	**Oil (bbl)**	**3,239,657,000**	**4,082,477,000**	**3,843,019,800**	**100%**	**NA**	**2,331.33**
Federal Total	**Oil (bbl)**	**806,678,253**	**998,046,653**	**923,755,471**	**24.04%**	**100%**	**539.45**
Onshore Total	**Oil (bbl)**	**177,855,107**	**386,859,944**	**282,946,564**	**7.36%**	**30.63%**	**220.17**

State	Mineral	2017	2021	5-year Average	% Total	% Federal	2021 Total CO_2e (Mt)
Kansas		130,210	69,620	113,957	0%	0.01%	0.04
New Mexico		82,139,821	259,760,846	167,533,624	4.36%	18.14%	147.85
Oklahoma		649,264	500,492	632,619	0.02%	0.07%	0.29
Texas		361,982	260,405	353,508	0.01%	0.04%	0.15
	Total Oil CO_2 Emissions - Kansas, New Mexico, Oklahoma, Texas						467.61
U.S. Total	**Gas (Mcf)**	**28,400,049,000**	**37,015,049,000**	**32,835,395,600**	**100%**	**NA**	**2,758.39**
Federal Total	**Gas (Mcf)**	**4,423,952,652**	**4,091,194,238**	**4,311,117,195**	**13.13%**	**100%**	**304.82**
Onshore Total	**Gas (Mcf)**	**3,238,793,013**	**3,295,391,578**	**3,320,351,752**	**10.11%**	**77.02%**	**245.46**
Kansas		3,936,913	2,674,203	3,441,182	0.01%	0.08%	0.2
New Mexico		787,309,387	1,313,730,502	1,043,258,032	3.18%	24.20%	97.86
Oklahoma		15,912,495	14,521,030	15,456,960	0.05%	0.36%	1.08
Texas		31,198,409	33,738,224	29,169,451	0.09%	0.68%	2.52
	Total Gas CO_2 Emissions - Kansas, New Mexico, Oklahoma, Texas						161.02
U.S. Total							**6,270.94**
Federal Total							**1,292.57**
Onshore Total							**913.93**

Source: BLM (2021a)

The 2021 BLM Specialist Report contains estimates of both direct and indirect (including downstream combustion) emissions from BLM-authorized fossil fuel development on the federal mineral estate for the three primary GHGs of concern (CO_2, CH_4, N_2O). In addition, the estimated emissions are aggregated at different scales for comparison with emissions reports and inventories completed by other entities at state, national, and global scales and for relevant industrial sectors. More details on the methods and assumptions can be found in Section 4.0 of the Specialist Report.

The BLM Specialist Report also discusses long-term projected annual trends in federal fossil fuel production, energy values, and GHG emissions out to year 2050 based on data obtained from the EIA's AEO report (EIA 2022). The AEO does not delineate production on a federal and non-federal basis (it only provides total U.S. production), and thus the BLM uses a 5-year average of actual federal production to provide a ratio from which to base the federal portion of future production forecasts. The projections are made by multiplying each year of data from the AEO report by the most current 5-year averages of federal production divided by the 5-year averages of total U.S. production for each fossil fuel mineral type.

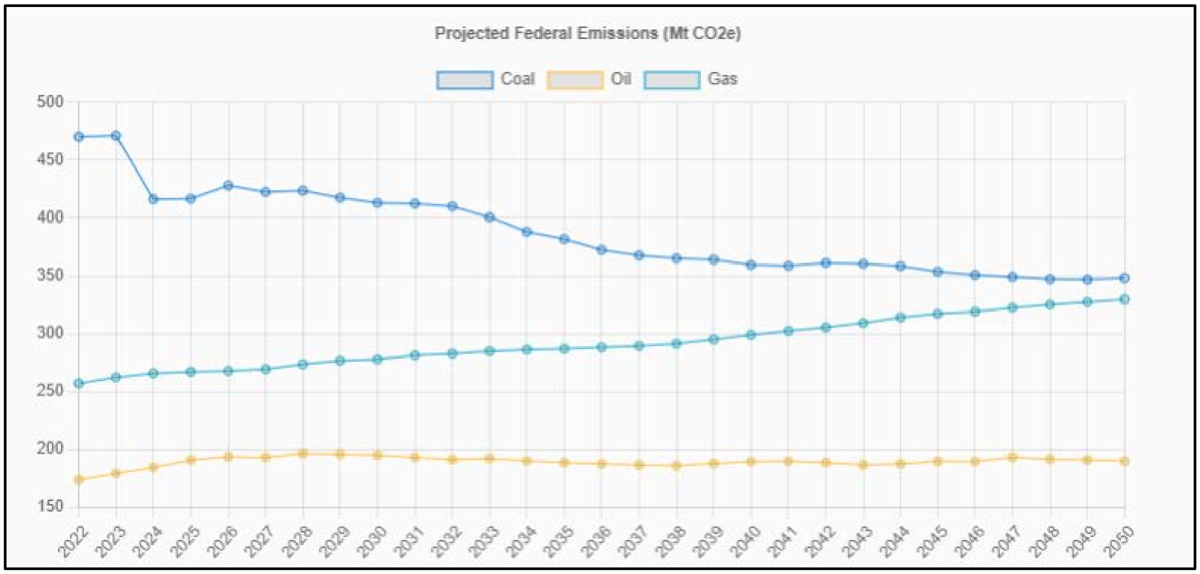


Figure 20. High economic growth long-term onshore federal mineral emissions

Table 26. provides the long-term cumulative sums of production, energy values, and GHG emissions projected out to year 2050 based on the AEO data shown in Figure 20 above. GHG emissions for future projections present only the high growth scenario; other scenarios can be found in the 2021 BLM Specialist Report and through EIA (BLM 2021a).

Table 26. Long-Term Federal Mineral Projections - AEO High Economic Growth

Federal Minerals	Production	Energy (Quads)	Emissions (Mt CO_2e)
Coal (MM short tons)	6,059.71	151.0687	10,755.71
Oil (MM bbl/d)	26.15	55.3137	5,431.36
Gas (trillion cubic feet)	109.27	110.7173	8,138.80
Projected Totals	NA	317.1	24,325.88

Notes: 5-year average ratio of fossil fuel historical production data equals federal (ONRR)/U.S. totals (EIA).
AEO reference case used for series projections, and totals are the sum of the series (2022–2050).

State-specific forecasts for New Mexico, Kansas, Texas, and Oklahoma are not presented in the BLM Specialist Report. However, coal, oil, and gas GHG emissions for year 2021 are presented in Table 25 for each of these states.

11.2.1 GLOBAL CLIMATE CHANGE PROJECTIONS

According to preliminary data estimates provided by the Rhodium Group (an independent research provider), cumulative global GHG emissions declined by approximately 4.4% in 2020, primarily due to economic effects of the COVID-19 pandemic. The EIA provides long-term (2020–2050) world energy and emissions projections in its International Energy Outlook (IEO). The most recent IEO that contains CO_2 emissions data is the IEO2021, released in October 2021. The IEO provides several different scenarios to forecast future energy needs and associated carbon emissions. The reference case reflects current trends and relationships among supply, demand, and prices in the future and is a reasonable baseline case to compare with cases that include alternative assumptions about the future energy system.

Similar to the AEO report, IEO provides a reference case that assumes energy consumption will rise nearly 50% between 2020 and 2050. According to the reference case projections, worldwide coal consumption declines through 2050, although certain developing countries may increase use due to either an abundance or proximity to the fuel or via the emergence of heavy industries that rely on coal. Natural gas consumption is forecast to grow by 31% through the projection period, which is limited by the projected growth in renewable energy sources (27% share in 2050). Constant petroleum growth is forecast for the entire projection period, with almost the entire supply going toward meeting transportation demand and growth. Global energy-related CO_2 emissions are projected to increase by 0.6% per year from 2020 to 2050 from about 35 billion metric tons CO_2 to about 43 billion metric tons. Although aggregate CO_2 emissions from the energy sector are projected to continue to rise, the carbon intensity of future energy sources (i.e., the amount of CO_2 emissions produced per unit of energy used) is projected to decrease, indicating that sources of energy that do not produce CO_2 emissions (e.g., renewables) will comprise a larger portion of meeting future energy demands. Figure 21 and Figure 22, which are EIA IEO graphs, show some of the historical and projected energy and emissions estimates derived from global fossil fuel use. Some of the data are displayed separately for countries that are a part of the Organization of Economic Cooperation and Development, of which the United States is a part, and those that are not.

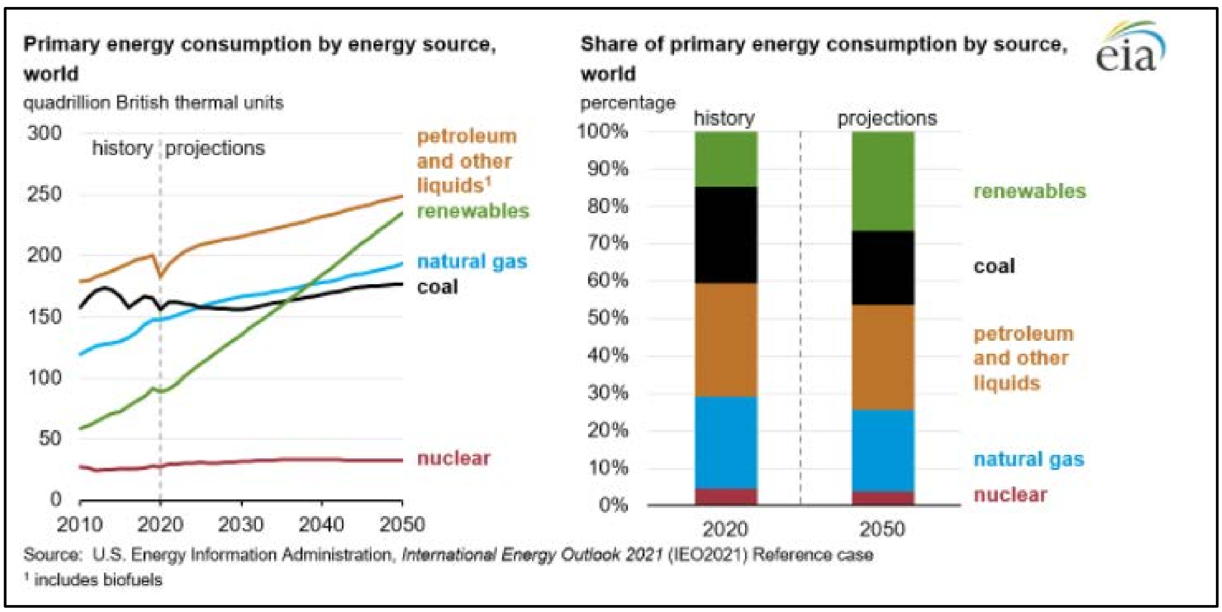


Figure 21. Primary energy consumption by energy source – global projections.

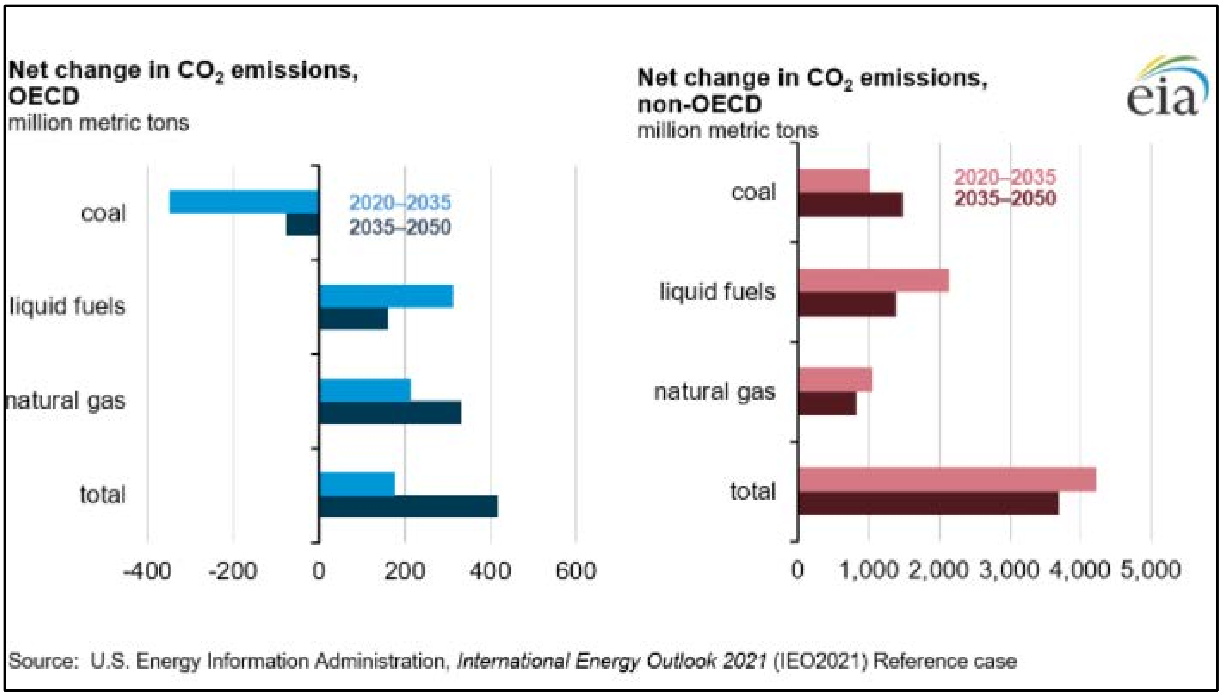


Figure 22. Net change in CO_2 emissions - global predictions

11.2.1.1 NEW MEXICO

Climate modeling suggests that annual average temperatures in this region may rise by 4°F to 6°F by the end of the twenty-first century, with warming increasing from south to north. By 2080 to 2090, the southwestern United States would see a 10% to 20% decline in precipitation, primarily in winter and spring, with more precipitation falling as rain. A recent U.S. Bureau of Reclamation report made the following projections through the end of the twenty-first century for the Upper Rio Grande Basin (southern Colorado to south-central New Mexico) based on the current and predicted future warming (U.S. Bureau of Reclamation et al. 2013):

- There would be decreases in overall water availability by one-quarter to one-third.
- The seasonality of stream and river flows would change, with summertime flows decreasing.
- Stream and river flow variability would increase. The frequency, intensity, and duration of both droughts and floods would increase.

The U.S. Bureau of Reclamation report also noted that reduction in water is expected to make environmental flows in the Upper Rio Grande system more difficult to maintain and reduce the shallow groundwater available to riparian vegetation. Both effects have implications for the habitat of fish and wildlife in the Upper Rio Grande Basin riparian ecosystems (U.S. Bureau of Reclamation et al. 2013).
A USFS assessment of 117 species of birds, reptiles, amphibians, and mammals along the Middle Rio Grande in New Mexico (Friggens et al. 2013 as cited in U.S. Bureau of Reclamation et al. 2013) projected decreasing availability of riparian habitat, and loss of mature trees due to fire and disease, that would directly and indirectly affect many species of birds and mammals. Most evaluated species were projected to experience negative effects from climate change; however, a few species that are considered generalists and highly adaptable, such as coyotes, jackrabbits, some lizards, and road

runners, may benefit from conversion of the riparian area associated with the Rio Grande to a more sparsely vegetated and drier habitat (Friggens et al. 2013 as cited in U.S. Bureau of Reclamation et al. 2013).

11.2.1.2 GREAT PLAINS

The Great Plains region (including Texas, Oklahoma, and Kansas) is projected to experience increases in temperatures and more frequent drought in the future. Temperature increases and precipitation decreases would stress the region's primary water supply, the Ogallala Aquifer. Seventy percent (70%) of the land in this area is used for agriculture. Threats to the region associated with climate change include

- pest migration as ecological zones shift northward,
- increases in weeds, and
- decreases in soil moisture and water availability (U.S. Bureau of Reclamation et al. 2013).

11.3 U.S. GEOLOGICAL SURVEY END-USE AND EXTRACTION ANALYSIS

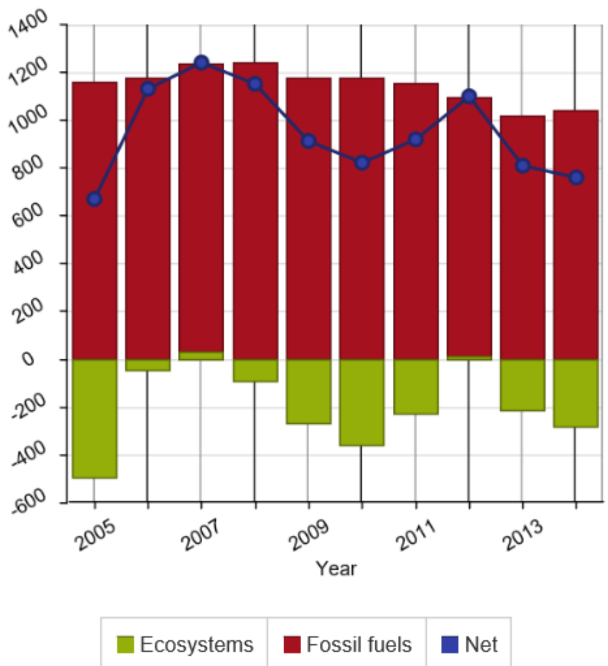
In November 2018, the USGS published a scientific investigation report, *Federal Lands Greenhouse Gas Emissions and Sequestration in the United States: Estimates 2005-2014* (Merrill et al. 2018). The report consists of a 44-page document with four companion datasets and an interactive online mapping site in which the user can pull up data for each state (28 states included in analysis) and two offshore sites. The data itself consists of 10 years of emissions and sequestration estimates in which the emissions from combustion and extraction activities on federal lands from fossil fuels is converted into CO_2e and measured in MMT/year of CO_2e. The estimates include the three most prominent GHGs: CO_2, CH_4, and N_2O. The results are presented by state and year and the estimates are broken into categories by the sector of the economy where the combustion or extraction related emissions occurred, or the biologic process being quantified occurred. The data presents both gross and net emissions after sequestration is accounted for. For the purpose of this analysis the BLM quantifies all emissions in CO_2e. For context of gross and net emissions as well as sequestration activities, the BLM shows the total U.S. and New Mexico emissions from combustion and extraction activities on federal lands as well as sequestration activity (Figure 23 and Figure 24). American Indian and Tribal lands were not included in the analysis. Additionally, the national total (gross) emissions include two offshore areas (Merrill et al. 2018).

11.3.1 GREENHOUSE GAS EMISSIONS (COMBUSTION AND EXTRACTION) FROM U.S. FEDERAL LANDS (CO_2e)

In 2014, end-use combustion and extraction of fossil fuels produced on U.S. federal lands was 1,332 MMT of CO_2e. This reported value includes emissions from the combustion of coal, oil and natural gas from fossil fuels produced on U.S. federal lands as well as extraction emissions from activities occurring on federal lands. When compared to 2005 emissions, this results in a decrease of emissions throughout all the three prominent GHG emissions. From 2005 to 2014, GHG emissions from end-use combustion and extraction of fossil fuels produced on federal lands have resulted in an overall trend of decreased emissions (see Figure 23). When compared to global and national total CO_2e emissions, 48,257 and 6,558.3 MMT respectively, from all sources (Table 27), CO_2e emissions from these activities (end-use combustion and extraction activities) of fossil fuels produced on federal lands is 2.8% and 19.4% respectively (EPA 2022p; World Resources Institute 2007). Of the 1,332 MMT CO_2e, 80.53 MMT were exported end-use combustion emissions, 752.50 MMT represented emissions from coal sources while 498.76 MMT were the result of oil and natural gas source. Figure 25 and Figure 26 provide a graphical representation of CO_2e emissions from the fossil fuels produced on U.S. federal lands associated with end-use combustion and extraction activities.

U.S. federal lands also contribute a great deal to the sequestration of CO_2 and provide carbon storage (sinks) for CO_2 emissions. In 2014 U.S. federal lands provided 283.2 MMT of carbon storage. U.S. federal lands sequestered an average of 195 MMT of CO_2e between 2005 and 2014 offsetting approximately 15% of the CO_2 emissions resulting from the extraction of fossil fuels on federal lands and their end-use combustion (see Figure 23) (Merrill et al. 2018).

National onshore CO_2 emissions and sequestration: 2005-14

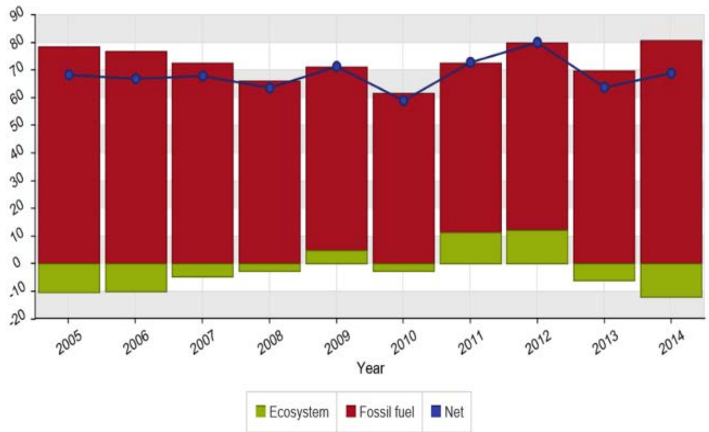


Year	Total fossil fuels	Onshore fossil fuels	Onshore ecosystems	Onshore net
2005	1,361.9	1,162.3	-493.5	668.8
2006	1,378.6	1,178.1	-47.4	1,130.7
2007	1,398.3	1,207.3	32.7	1,240.0
2008	1,427.9	1,243.7	-92.3	1,151.4
2009	1,422.5	1,178.5	-266.6	911.9
2010	1,429.4	1,180.6	-359.5	821.1
2011	1,362.4	1,156.2	-237.5	918.7
2012	1,280.5	1,085.8	13.0	1,098.8
2013	1,210.5	1,022.3	-213.6	808.7
2014	1,279.0	1,042.2	-283.2	759.0

Figure 23. National CO_2 emissions (fossil fuels) and sequestration (ecosystems): 2005–2014

Source: Merrill et al. (2018).

All values are in million metric tons of CO_2 equivalent (MMT CO_2e). Total fossil fuels include offshore emissions from two areas.



Year	Gross Fossil Fuels CO_2, CH_4 and N_2O	Onshore ecosystems	Net Fossil Fuels
2005	91.40	-10.5	80.9
2006	89.48	-10.2	79.28
2007	84.36	-4.8	79.56
2008	78.94	-2.8	76.14
2009	78.65	4.7	83.35
2010	73.74	-2.9	70.84
2011	72.44	11.1	83.54
2012	78.18	12	90.18
2013	80.68	-6.1	74.58
2014	91.63	-12	79.63

Figure 24. New Mexico CO_2 emissions (fossil fuels) and sequestration (ecosystems): 2005–2014

Source: Merrill et al. (2018).

While the USGS total values include GHG emissions from end-use combustion and from extraction activities of coal, oil and gas, in this section the BLM focuses on the end-use combustion emissions generated from the oil and natural gas sector (Table 27; Figure 25 and Figure 26).

Table 27. GHG Emissions, Combustion and Extraction, from U.S. Federal Lands (CO_2e)

Level/Sector	MMT CO_2e
Global emissions, all sources	48,257
National emissions, all sources*	5,981.4
End-use C&E emissions (federal lands)(1),(2)	1,332
% end-use C&E emissions (federal lands) to global emissions(2)	2.76
% end-use C&E emissions (federal lands) to national emissions(2)	22.27
End-use combustion only emissions (federal lands)(2)	1,201
% end-use combustion only emissions (federal lands) to global emissions(2)	2.49
% end-use combustion only emissions (federal lands) to national emissions(2)	20.08
Extraction only emissions (federal lands)(2)	50.52
% of extraction only emissions (federal lands) to global emissions(2)	0.10
% of extraction only emissions (federal lands) to national emissions(2)	0.84
End-use C&E emissions (federal lands) O&G only(3)	499
% end-use C&E emissions (federal lands) O&G only to global emissions(3)	1.03
% end-use C&E emissions (federal lands) O&G only to national emissions(3)	8.34
End-use combustion only emissions (federal lands) O&G only(3)	460
% end-use combustion only emissions (federal lands) O&G only to global emissions(3)	0.95

Level/Sector	MMT CO_2e
% end-use combustion only emissions (federal lands) O&G only to national emissions[3]	7.69
Extraction only emissions (federal lands) O&G only[3]	38.76
% extraction only emissions (federal lands) O&G only to global emissions[3]	0.08
% extraction only emissions (federal lands) O&G only to national emissions[3]	0.65

Sources: EPA (2022p); Merrill et al. (2018); World Resources Institute (2017)

C&E = combustion and extraction

Global emissions represented are for 2013, national emissions and federal land emissions are for 2014.

O&G = oil and gas

* Emissions reflect data from 2020 EPA GHG Inventory report, newer inventories may correct this value somewhat.

[1] Includes 80.53 MMT of exported CO_2e emissions. Emission totals are CO_2 1,290 MMT, CH_4 47.6 MMT of CO_2e, N_2O 5.5 MMT of CO_2e.

[2] Includes emissions from coal, oil, and natural gas.

[3] Isolates coal from the total and only includes oil and natural gas CO_2e emissions.

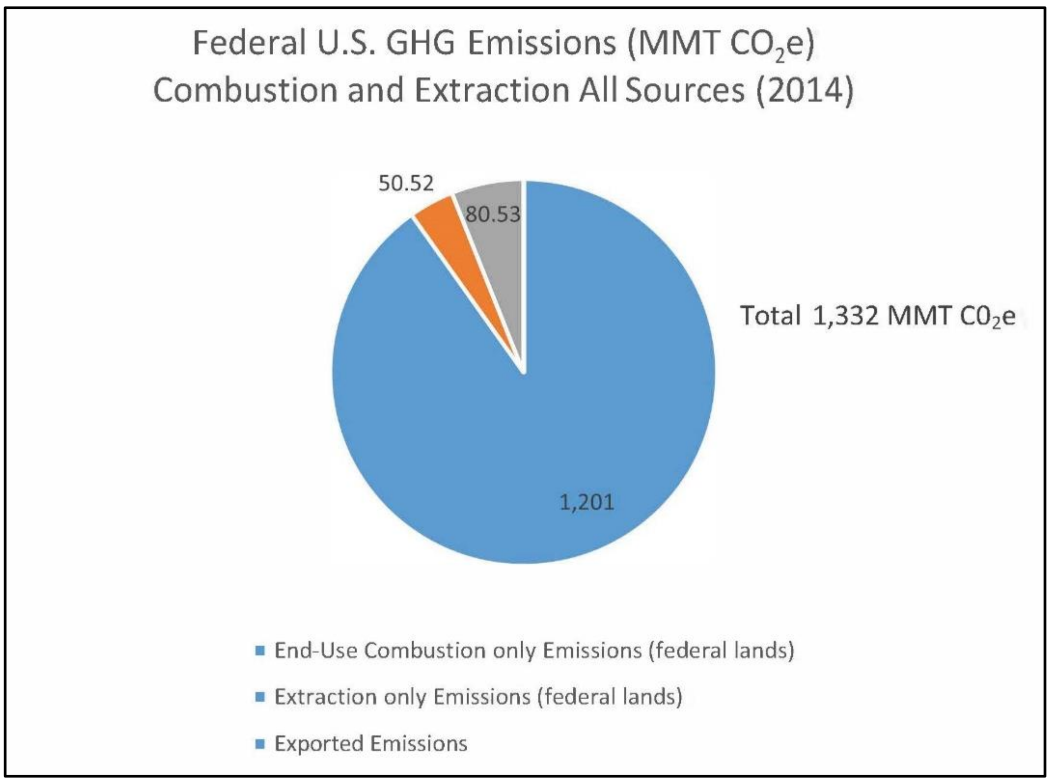


Figure 25. Federal U.S. GHG emissions, combustion and extraction, all sources (2014).

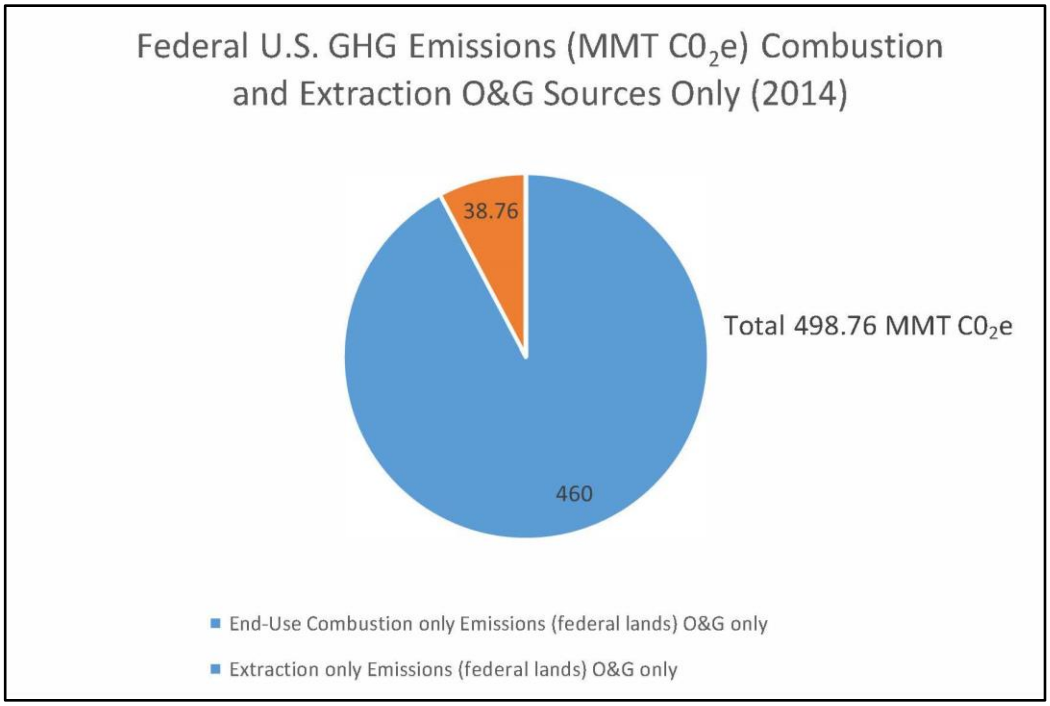


Figure 26. Federal U.S. GHG emissions, combustion and extraction, oil and gas sources only (2014).

11.3.2 GREENHOUSE GAS EMISSIONS (COMBUSTION AND EXTRACTION) FROM NEW MEXICO FEDERAL LANDS (CO_2e)

In 2014, end-use combustion and extraction of fossil fuels produced on New Mexico federal lands was 91.63 MMT CO_2e. This reported value includes emissions from the combustion of coal, oil, and natural gas from fossil fuels produced on federal lands, as well as extraction emissions from activities occurring on federal lands. When compared with 2005 emissions, this results in increased emissions for all three prominent GHGs. From 2005 to 2014, GHG emissions from end-use combustion and extraction of fossil fuels produced on federal lands have resulted in average annual emissions of 81.95 MMT CO_2e (see Figure 25 and Figure 26). When compared with global and national total CO_2e emissions, 48,257 and 5,981.4 MMT, respectively, from all sources (Table 28), CO_2e emissions from these activities (end-use combustion and extraction activities) of fossil fuels produced on New Mexico federal lands is 0.19% and 1.53%, respectively (EPA 2022p; World Resources Institute 2017).

In 2014, New Mexico federal lands provided 12 MMT of carbon storage. Federal lands sequestered an average of 9.5 MMT of CO_2e between 2005 and 2014 (Figure 27) (Merrill et al. 2018). While the USGS total values include GHG emissions from end-use combustion and from extraction activities of coal, oil, and gas, for the purposes of this analysis, the BLM focuses on only the end-use combustion emissions generated from the oil and natural gas sector; the BLM excluded coal totals (Table 28 and Figure 28).

Table 28. GHG Emissions, Combustion and Extraction, from BLM New Mexico (CO_2e)

Level/Sector	MMT CO2e
Global emissions, all sources	48,257

Level/Sector	MMT CO2e
National emissions, all sources*	5,981.4
End-use C&E emissions (New Mexico federal land)[(1), (2)]	91.63
% end-use C&E emissions (New Mexico federal land) to global emissions[(2)]	0.19
% end-use C&E emissions (New Mexico federal land) to national emissions[(2)]	1.53
End-use combustion only emissions (New Mexico federal land)[(2)]	73
% end-use combustion only emissions (New Mexico federal land) to global emissions[(2)]	0.15
% end-use combustion only emissions (New Mexico federal land) to national emissions[(2)]	1.22
Extraction only emissions (New Mexico federal land)[(2)]	12.76
% of extraction only emissions (New Mexico federal land) to global emissions[(2)]	0.03
% of extraction only emissions (New Mexico federal land) to national emissions[(2)]	0.21
End-use C&E emissions (New Mexico federal land) O&G only[(3)]	66.35
% end-use C&E emissions (New Mexico federal land) O&G only to global emissions[(3)]	0.14
% end-use C&E emissions (New Mexico federal land) O&G only to national emissions[(3)]	1.11
End-use combustion only emissions (New Mexico federal land) O&G only[(3)]	54.58
% end-use combustion only emissions (New Mexico federal land) O&G only to global emissions[(3)]	0.11
% end-use combustion only emissions (New Mexico federal land) O&G only to national emissions[(3)]	0.91
Extraction only emissions (New Mexico federal land) O&G only[(3)]	11.77
% extraction only emissions (New Mexico federal land) O&G only to global emissions[(3)]	0.02
% extraction only emissions (New Mexico federal land) O&G only to national emissions[(3)]	0.20

Sources: EPA (2022p); Merrill et al. (2018); World Resources Institute (2017)

C&E=combustion and extraction

Global and state-wide emissions represented are for 2013, national emissions and federal land emissions are for 2014.

O&G=oil and gas

* Emissions reflect data from 2017 EPA GHG Inventory report, newer inventories may correct this value somewhat.

(1) Includes 5.86 MMT of exported CO_2e emissions. Emission totals are CO_2 74.78 MMT, CH_4 10.78 MMT of CO_2e, N_2O 0.22 MMT of CO_2e

(2) Includes emissions from coal, oil, and natural gas

(3) Isolates coal from the total and only includes oil and natural gas CO_2e emissions

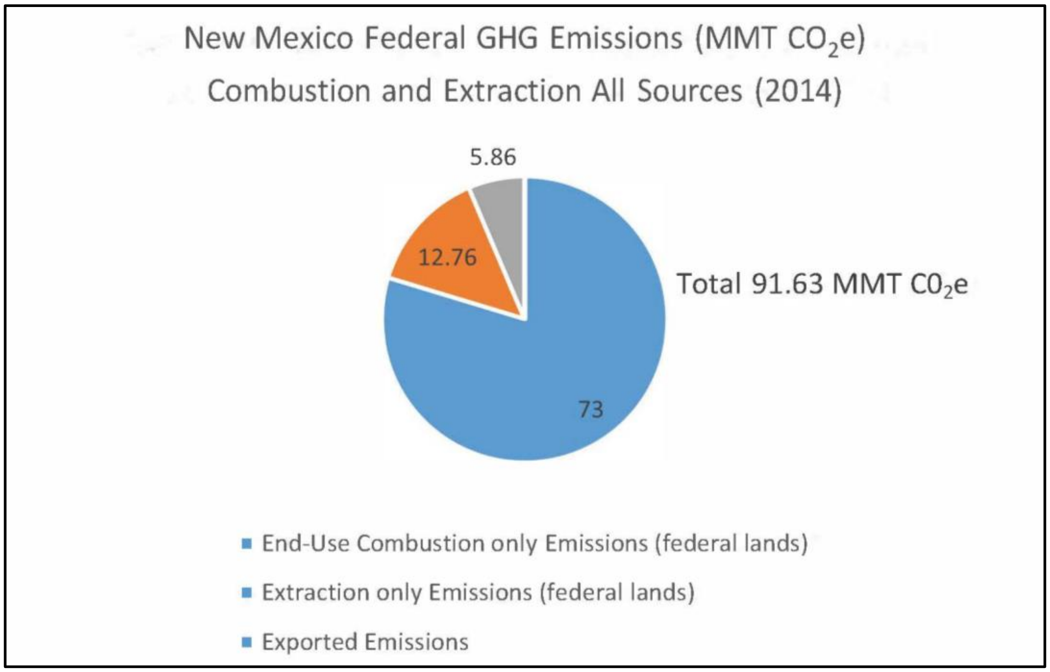


Figure 27. New Mexico federal GHG emissions, combustion and extraction, all sources (2014).

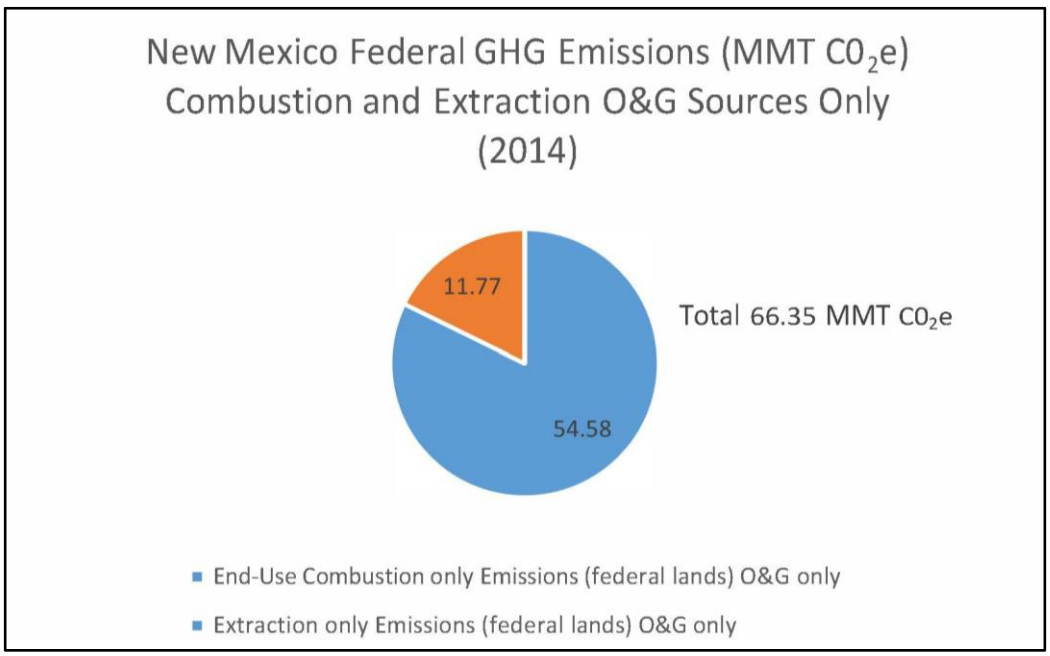


Figure 28. New Mexico federal GHG emissions, combustion and extraction, oil and gas sources only (2014).

11.4 REASONABLY FORESEEABLE FUTURE ACTIONS AFFECTING GREENHOUSE GAS EMISSIONS

Overall, total New Mexico statewide gross GHG emissions are expected to decrease (CNEE 2020). The New Mexico Greenhouse Gas Inventory and Forecast Report 2020 projects the following for year 2030 in New Mexico for emissions produced within the state (i.e., production-based emissions):

- Gross GHG emissions of 96.6 MMT CO_2e—an increase of 22% relative to 2005 and a decrease 15% relative to 2018. New Mexico's emissions are more than twice the national average of GHG emissions per capita. New Mexico's high per capita emissions are largely the result of a GHG-intensive oil and gas industry, which makes up a significant portion of overall GHG emissions profile.
- Top sources of GHG emissions: transportation fuel use (15.4 MMT CO_2e,) electricity generation (12.9 MMT CO_2e,) and oil and gas (fugitive and fuel emissions) (32.5 MMT CO_2e). Transportation fuel and electricity generation decreased over 2005 estimates, but oil and gas increased.
- Approximately 43 MMT of CO_2e are projected as a result of oil and natural gas production, processing, transmission, and distribution. This is 44.5% of the gross New Mexico emissions (a slight decrease compared with the relative contribution of oil and gas production in 2018, 53.0%, and an increase compared with the relative contribution of oil and gas production in 2005, 25.0%).

All scenarios see a significant rise in emissions from 2005 to 2018, as well as a significant drop from 2018 to 2023, driven primarily by the NSPS for the oil and gas sector (CNEE 2020).

12 OTHER TOPICS

12.1 FOUR CORNERS AIR QUALITY TASK FORCE

In 2002, NMED and local governments convened to sign an Early Action Compact for O_3 under an EPA program that required commitment for state and local action to resolving O_3 issues prior to a nonattainment designation. In 2005, the states of Colorado and New Mexico convened a group of stakeholders, then known as the FCAQTF, to address air quality issues in the Four Corners region in light of continued energy development and growth in the region and consider options for mitigating air pollution. A report detailing a wide range of mitigation options was published in November 2007 (FCAQTF 2007).

In 2008, its task complete, the group became known as the Four Corners Air Quality Group (FCAQG) and continued on as a forum for discussion of existing air quality issues and potential solutions. The FCAQG is currently composed of more than 100 members and 150 interested parties representing a wide range of perspectives on air quality in the Four Corners region. Members include private citizens, representatives from public interest groups, universities, industry, state, tribal and local governments, and federal agencies. The BLM has been an active participant from the beginning and maintains a representative on the steering committee. The last FCAQG met virtually on November 15 and 16, 2021. For more information visit the FCAQG at the NMED website at https://www.env.nm.gov/air-quality/four-corners-air-quality-group/.

12.2 ELECTRICAL GENERATING UNITS

There are two coal-fired electrical generation units (EGUs) in the Four Corners area: the San Juan Generating Station, located 15 miles west of Farmington, New Mexico; and the Four Corners Power Plant, located on Navajo Nation land in Fruitland, New Mexico. These EGUs are the primary source of several criteria air pollutants in the FFO area, including SO_2 (85%), NO_x (41%), and $PM_{2.5}$ (3%) (EPA 2020b). EGUs are responsible for 31% of New Mexico GHG emissions and 31% of U.S. GHG emissions (NMED 2016).

In 2013, NMED, Public Service Company of New Mexico, and EPA agreed to meet the requirements of the federal Regional Haze Rule through the shutdown of two units at the San Juan Generating Station by the end of 2017. The agreement also requires the installation of selective non-catalytic reduction technology on the remaining two units. This resulted in significant reductions from the previous emissions levels of many pollutants: a 67% reduction in SO_2, a 62% reduction in NO_x, a 50% reduction in PM, a 44% reduction in CO, a 51% reduction in VOC, a 50% reduction in CO_2 and a 50% reduction in mercury. The New Mexico Environmental Improvement Board approved a revision to the SIP containing the agreement requirements in the fall of 2013.

In December 2013, three coal-fired generators were shut down at the Four Corners Power Plant as part of a plan to meet the requirements of the federal Regional Haze Rule. The remaining two coal-fired generators had selective catalytic reduction technology installed in 2018. These changes satisfy BART requirements from EPA. This will result in significant reductions from current emissions levels of many pollutants: a 36% reduction in NO_x, a 61% reduction in mercury, a 43% reduction in PM, a 30% reduction in CO_2, and a 24% reduction in SO_2. In Texas, NO_x emissions from EGUs in O_3 nonattainment areas (Beaumont-Port Arthur, Dallas-Fort Worth and Houston-Galveston-Brazoria) are required to limit NO_x emissions from utility boilers, auxiliary steam boilers, stationary gas turbines and duct burners under 30 TAC § 117(c). The Texas-proposed regional haze SIP did not require BART-eligible EGUs to install controls because the State of Texas determined the impact of each plant's emissions did not significantly degrade visibility in a Class I area, or facilities had already reduced emissions or shut down units. On December 16, 2014, the EPA proposed to partially disapprove the Texas regional haze SIP and also proposed a Federal Implementation Plan to require SO_2 emissions reductions at 15 Texas BART-eligible sources.

In Oklahoma, Tulsa Public Service Company of Oklahoma retired one coal-fired unit at Oologah in April 2016 and installed a dry sorbent injection system on a second coal-fired unit at the same time. The second unit will be shut down by December 31, 2026, to meet the requirements of the federal Regional Haze Rule. In 2016, SO_2 emissions were reduced by 78% and NO_2 emissions were reduced by 81%. In 2011, EPA disapproved the Oklahoma SIP revision plan for controls at Oklahoma Gas and Electric's Sooner and Muskogee Units and the AEP/PSO Northeastern Units 3 and 4. The EPA determined that dry scrubber control technology was needed at these units to meet federal haze rule requirements. The disapproval has been challenged by the State of Oklahoma, upheld by the courts and has now been appealed to the Supreme Court by the State of Oklahoma. Oklahoma submitted a SIP revision in 2013 that was approved by EPA in March 2014 that revises the BART determination for AEP/PSO Units 3 and 4. The revised determination included short-term compliance with emissions limits, shut down of one of the units by April 16, 2016, and shut down of the other unit by December 31, 2026.

In Kansas, emissions at four coal-fired units were significantly reduced as a result of the federal Regional Haze Rule. At Kansas City Power and Electric's La Cygne plant, selective catalytic reduction (SCR) was installed on both units and scrubbers were installed. This resulted in 83% reduction in NO_x emissions and 82% reduction in SO_2 emissions. At Westar's Jeffrey coal-fired units, installing low-NO_x burners and switching to natural gas combustion resulted in an 82% reduction in NO_x emissions and a 34% reduction in SO_2 emissions.

12.3 INFRARED CAMERAS

The BLM has two infrared cameras that are being used to detect leaks and fugitive emissions. BLM inspectors carry these cameras into the field and have been able to alert operators of equipment requiring repair or maintenance. At this time, the cameras are being used in an advisory rather than a regulatory role.

12.4 FOUR CORNERS METHANE HOTSPOT

In 2014, pioneering research using space-borne (satellite and aircraft) determinations of CH_4 concentrations indicated anomalously large CH_4 concentrations in the Four Corners region, including the northern portion of the Farmington planning area (Kort et al. 2014). A subsequent study (Schneising et al. 2014) also indicated larger anomalies over other oil and gas basins in the United States. This results from nighttime/early morning trapping of CH_4 (as well as non-CH_4 hydrocarbons) in low-lying areas due to the San Juan Basin's topography and prevailing meteorological conditions. CH_4 is 34 times more potent at trapping GHG emissions than CO_2 when considering a time horizon of 100 years (IPCC 2013).

Sources contributing to the hotspot include fossil fuel operations, 66% to 75% of which is clearly attributed to natural gas and coalbed CH_4 operations (Pétron et al. 2020). A significant amount of CH_4 is emitted during oil and gas well completion. CH_4 is also emitted from process equipment, such as pneumatic controllers and liquid unloadings, at oil and gas production sites. Ground-based, direct source monitoring of pneumatic controllers conducted by the Center for Energy and Environmental Resources show that CH_4 emissions from controllers exhibit a wide range of emissions and a small subset of pneumatic controllers emitted more CH_4 than most (Allen, Pacsi, et al. 2014). Emissions measured in the study varied significantly by region of the United States, the application of the controller and whether the controller was continuous or intermittently venting. The Center for Energy and Environmental Resources had similar findings of variability of CH_4 emissions from liquid unloading (Allen, Sullivan, et al. 2014).

In 2016, the results from an April 2015 study were released in which researchers conducted further ground-based and space-borne studies utilizing emerging pollutant measurement technology. The NASA Jet Propulsion Laboratory conducted these studies using two of its airborne spectrometers to identify and measure more than 250 individual sources of CH_4. The sources emitted the gas at rates ranging from a few pounds to 11,000 pounds (5,000 kg) per hour (NASA 2016). Overall, observed sources included gas processing facilities, storage tanks, pipeline leaks, and well pads, as well as a coal mine venting shaft. Using equipment enhancements and inferred fluxes, the CH_4 plumes showed that the top 10% of emitters contributed 49% to 66% to the inferred total point source flux of 0.23 teragram (Tg)/year to 0.39 Tg/year. Results are published at the Proceedings of the National Academy of Sciences in a paper entitled *Airborne methane remote measurements reveal heavy-tail flux distribution in Four Corners region* (Frankenburg et al. 2016).

Information on CH_4 may also be found in a new interactive mapping tool launched by NMED in 2019. This tool shows CH_4 hotspot information as well as information on CH_4 permits. The mapping tool shows elevated CH_4 levels along the northern border of San Juan County and western border of Rio Arriba County, New Mexico, and along the southern borders of Montezuma County and La Plata County, Colorado. It also provides locations of NMED-permitted oil and gas wells and tank batteries for permits greater than 10 tons of CH_4 emissions per year. These sources are concentrated along State Route 550 in San Juan, Rio Arriba, and Sandoval Counties, northeast of Chaco Culture National Historical Park (NMED 2019b).

In 2021, an aerial survey of the Permian Basin was conducted by Carbon Mapper, a partnership of university researchers and NASA's Jet Propulsion Laboratory. This survey utilized the NASA AVIRIS instrument, which is an airborne infrared spectrometer that measures wavelengths in light to detect and quantify the unique chemical fingerprint of CH_4 in the atmosphere. The instrument then measures the mass of CH_4 in the air and the length of the plume. Carbon Mapper takes into account the wind speed at the site to estimate the hourly emissions rate, averaged over multiple overflights. The group documented massive amounts of CH_4 venting into the atmosphere from oil and gas operations across the Permian Basin, a 250-mile-wide bone-dry expanse along the Texas-New Mexico border. Carbon Mapper identified the spewing sites only by their GPS coordinates. The Associated Press (AP) took the coordinates of the 533 "super-emitting" sites and cross-referenced them with state drilling permits, air quality permits, pipeline maps, land records, and other public documents to piece together the corporations most likely responsible (Biesecker and Wieffering 2022).

The U.S. government maintains an inventory of CH_4 released into the atmosphere, which is used by policymakers and scientists to calculate the degree to which the planet will warm in the coming decades. The AP found that this government database often fails to account for the true rate of emissions observed in the Permian Basin. The EPA requires companies to report to its Greenhouse Gas Reporting Program emissions above the equivalent of 25,000 tons of CO_2 per year. Only a few dozen sites in the Permian Basin reported exceedances of that threshold for CH_4. The AP's analysis, however, found that more than 140 of the super-emitting facilities identified by Carbon Mapper were on track to exceed the reporting limit. Other companies also reported CH_4 emissions at levels far lower than those observed by Carbon Mapper, even when those values were adjusted to take into account overflights where no emissions were recorded.

13 MITIGATION

The reduction of air pollutant and GHG emissions from oil and gas operations has been the subject of much study and discussion in recent years. While there are a wide range of mitigation strategies available, for the most part, these strategies must be applied on a case-by-case basis at the project level. The EPA Natural Gas STAR Program established in 1993 has been a leader in developing and analyzing strategies to reduce CH_4 emissions (EPA 2022r). These reductions can help to control not only GHGs but also VOCs, which contribute to O_3 formation. Numerous opportunities for emissions reduction, including funds to assist with implementation, are documented on the EPA's Natural Gas STAR website. Each year, partners submit annual reports documenting their previous year's CH_4 emission reduction activities. Since the inception of the program, as of November 9, 2021, partners have eliminated 1.72 trillion cubic feet of CH_4 emissions by implementing 153 cost-effective technologies and practices. These technologies and practices, as well as other methods of reducing emissions, are discussed below.

In 2015, EPA Natural Gas STAR partner companies operated 51% of the active federal wells in the New Mexico portion of the San Juan Basin and 13% of the active federal wells in the New Mexico portion of the Permian Basin. In addition, Natural Gas STAR partner companies operated 5%, 11%, and 33% of the active federal wells in Kansas, Oklahoma, and Texas, respectively (BLM 2014). The EPA has found Natural Gas STAR partners' actions to result in measurable decreases in GHG emissions since the program's implementation. In October 2012, the EPA promulgated air quality regulations controlling VOC emissions at hydraulically fractured gas wells. These rules require air pollution mitigation measures that reduce the emissions of VOCs. These same mitigation measures have a co-benefit of reducing CH_4 emissions.

The Natural Gas STAR Methane Challenge Program is a voluntary program founded by the EPA in collaboration with oil and natural gas companies. The program recognizes companies that make specific and transparent commitments to reduce CH_4 emissions. More than 60 companies from all segments of the industry—production, gathering and boosting, transmission and storage, and distribution—are now program partners.

The EPA has NSPS (codified in 40 C.F.R. 60) in place to reduce VOC emissions from oil and gas sources. NSPS OOOO requires reduction of VOCs from well completion operations and storage tanks constructed after August 23, 2011. NSPS OOOOa requires reduction of VOCs from well completion operations from new or refractured hydraulically fractured wells and requires reduction of storage tank emissions by 95% for tanks constructed after September 18, 2015, with emissions greater than 6 tpy of VOCs (this has the co-benefit of reducing CH_4 emissions as well). NSPS OOOOa also imposes semiannual leak detection and repair requirements for the collection of fugitive emission components at well sites constructed after September 18, 2015, that produce more than 15 bbl of oil and/or gas per day. NSPS OOOOa also requires scheduled maintenance and/or emission control devices for reciprocating and centrifugal compressor venting at compressor stations and includes provisions to limit emissions from natural gas pneumatic devices and pumps. Following the 2020 amendment to OOOO and OOOOa, fugitive emissions monitoring is required only for those wells producing greater than 15 bbl per day. These provisions aim to reduce fugitive emissions of VOCs at oil and gas facilities.

In addition, Executive Orders (EOs) and memoranda issued to address the climate crisis have focused on GHG emission reductions and increased renewable energy production. The following is a summary of two of the EOs:

EO 13990, issued on January 25, 2021, focuses on protecting public health and directs all executive departments and agencies to immediately commence work to confront the climate crisis with the goal to improve public health and the environment. Two key directives in this EO are 1) the establishment of an Interagency Working Group on the Social Cost of Greenhouse Gases tasked with developing and promulgating costs for agencies to apply during cost-benefit analysis and 2) the rescission of the CEQ draft guidance entitled "Draft National Environmental Policy Act Guidance on Consideration of Greenhouse Gas Emissions" (Federal Register 84:30097) (June 26, 2019). The EO also directs the Secretary of the Interior to place a temporary moratorium on all oil and gas activities in the Arctic National Wildlife Refuge, revokes the permit for the Keystone XL pipeline, and requires all agency heads to review any agency activity under the prior administration to ensure compliance with the current administration's environmental policies.

EO 14008, issued on January 27, 2021, directs the executive branch to establish climate considerations as an element of U.S. foreign policy and national security and to take a government-side approach to the climate crisis. This EO reaffirms the decision to rejoin the Paris Agreement, commitments to environmental justice and new clean infrastructure projects, establishing a National Climate Task Force, and puts the United States on a path to achieve net-zero emissions by no later than 2050. Specific directives for the U.S. Department of the Interior and the BLM include increasing renewable energy production on public land and waters, performing a comprehensive review of potential climate and other impacts from oil and natural gas development on public land, establishing a civilian climate corps, and working with key stakeholders to achieve a goal of conserving at least 30% of the nation's lands and waters by 2030.

The NMED developed the Oil and Natural Gas Regulation for Ozone Precursors (NMAC 20.2.50), which went into effect August 5, 2022. Approximately 50,000 wells and associated equipment are subject to this regulation. It is anticipated that the regulation will annually reduce VOC emissions by 106,420 tons, NO_x emissions by 23,148 tons, and CH_4 emissions by 200,000 to 425,000 tons. The regulation includes emissions reduction requirements for compressors, engines and turbines, liquids unloading, dehydrators, heaters, pneumatics, storage tanks, and pipeline inspection gauge launching and receiving. The regulation also encourages operators to stop venting and flaring and use fuel cells technology to convert CH_4 to electricity at the well site and incentivizes new technology for leak detection and repair.

The NMED and New Mexico Energy, Minerals and Natural Resources Department are each in the process of developing rules that will regulate CH_4 emissions. The departments were charged with this task under the Executive Order on Addressing Climate Change and Energy Waste Prevention (January 13, 2019). The order instructs the departments to "jointly develop a statewide, enforceable regulatory framework to secure reductions in oil and gas sector methane emissions and to prevent waste from new and existing sources and enact such rules as soon as practicable." The Natural Gas Waste Reduction Rule will reduce unnecessary natural gas venting and flaring from new and existing sources. Provisions will reduce CH_4 emissions based on stringent limitations on natural gas venting that results in non-combustible CH_4 emissions. Additionally, recovery and reuse of natural gas will reduce flaring of CO_2, CH_4, and N_2O emissions.

A report by the U.S. Government Accountability Office (2010) noted that opportunities exist for capturing fugitive emissions from venting and flaring of natural gas on wells under federal jurisdiction. A report prepared for the BLM in Montana includes an entire chapter on reduction of emissions of GHGs (URS 2010). Another report recently issued by the USFS summarizes and builds on work originally done by the BLM to identify best management practices for protection of air quality during oil and gas development and production (USFS 2011). Rapid development could result in an increase of criteria and HAP emissions in the planning areas. Limiting development through a phased approach could help to reduce concentrations of emissions in the air basins.

The shutdown of two of the units at the San Juan Generating Station in December 2017 will result in substantial decreases in emissions, including a 67% reduction in SO_2, a 62% reduction in NO_x, a 50% reduction in PM, a 44% reduction in CO, and a 51% reduction in VOCs. Additionally, selective catalytic reduction technology installed on the two remaining coal-fired generators at the Four Corners Power Plant will result in additional reductions in emissions from the facility, including a 36% reduction in NO_x, 43% reduction in PM, and 24% reduction in SO_2. On June 30, 2022, one of the two remaining units was shut down, and the San Juan Generating Station is proposed for full closure by October 2022, which would result in even further drops in future pollutant emissions for the analysis area. New Mexico will need to comply with the federal Regional Haze Rule requirements as it develops its SIP for the second planning period. EPA promulgated revisions to the Regional Haze Rule in 2017 and, in August 2019, issued its *Guidance on Regional Haze State Implementation Plans for the Second Implementation Period*. Since that time, air agencies and other stakeholders, including industry, conservation organizations, and federal land managers have raised various questions regarding Regional Haze Rule requirements as part of their SIP development for the second planning period. New Mexico is currently in the 2021 regional haze planning process and is in the process of updating its regional haze SIP. The submittal of the Proposed SIP to EPA Region 6 is expected in 2022 (NMED 2021b).

Texas proposed a 2021 regional haze SIP Revision that is designed to address regional haze in Big Bend and Guadalupe Mountains National Parks in Texas and Class I areas located outside of Texas that may be affected by emissions from within the state. On June 30, 2021, the commission adopted the 2021 regional haze SIP revision (Project No. 2019-112-SIP-NR). The SIP revision demonstrates compliance with the regional haze requirements of Section 169A of the federal CAA and the EPA's Regional Haze Rule for the second planning period (TCEQ 2022c).

As part of the process of developing Oklahoma's 2021 regional haze SIP, the ODEQ AQD identified 12 facilities that are reasonably anticipated to impact visibility conditions at the Wichita Mountains Wilderness Area and identified 21 sources in neighboring states that are reasonably anticipated to impact visibility conditions at the Wichita Mountains Wilderness Area (including sources in Texas) and have asked these states to consider the potential impact of the sources identified within their states for further analysis as part of the process for developing their 2021 regional haze SIP. The SIP is currently in the second planning period with public comments ending in July 2022 (ODEQ AQD 2021).

Cumulatively, it is expected that future levels of criteria pollutant, VOC, HAP, and GHG emissions related to oil and gas operations would be lower than current levels due to the aforementioned factors. However, there will be increases in emissions associated with reasonably foreseeable oil and gas development and future potential development of leases.

While it is beyond the scope of this report to detail the wide range of mitigation strategies available, it must be noted that, for the most part, these strategies must be applied on a case-by-case basis at the project level.

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15 APPENDICES

15.1 APPENDIX A NATIONAL EMISSIONS INVENTORY (NEI)

15.2 APPENDIX B NATIONAL AIR TOXICS ASSESSMENT (NATA)

15.3 APPENDIX C CLIMATE NORMALS

15.4 APPENDIX D MAJOR SOURCES (NEI)

15.5 APPENDIX E DEPOSITION CHARTS

15.6 APPENDIX F CALCULATORS