U.S. Department of the Interior
Bureau of Land Management - Farmington Field Office
Bureau of Indian Affairs - Navajo Regional Office

February 2020

Farmington Mancos-Gallup

Draft Resource Management Plan Amendment and Environmental Impact Statement

Volume 2

MISSION STATEMENTS

BLM

It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations.

BIA

The Bureau of Indian Affairs' mission is to enhance the quality of life, to promote economic opportunity, and to carry out the responsibility to protect and improve the trust assets of American Indians, Indian tribes, and Alaska Natives.

Cover Photo: View of Angel Peak Scenic Area. Photo taken by EMPSi.

APPENDICES

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Appendix A

Figures

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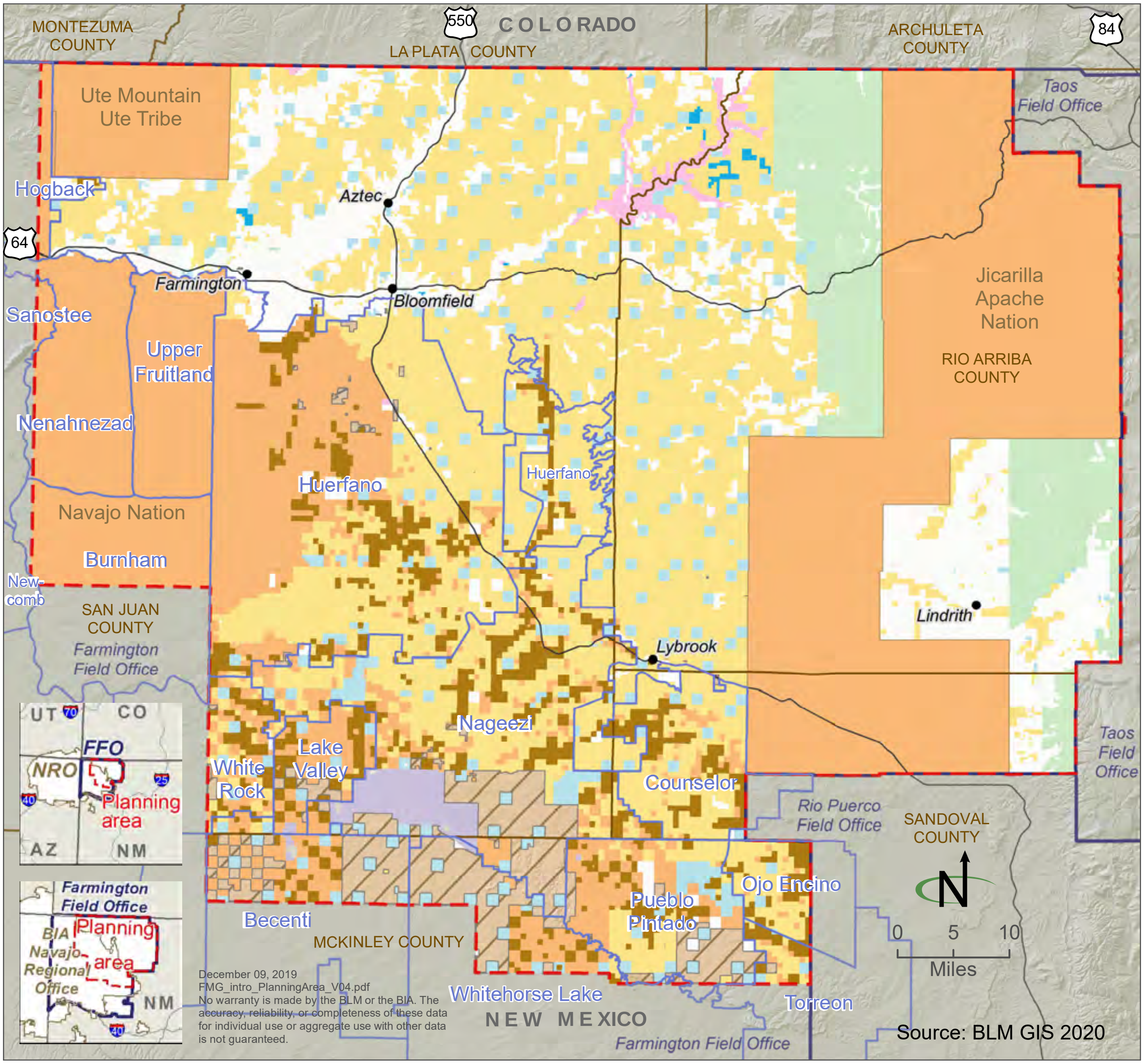
FIGURES

Figure 1-1
Planning Area

The planning area consists of a portion of the FFO and NRO in San Juan, Rio Arriba, McKinley, and Sandoval Counties, including lands managed by the BLM, BIA (Tribal trust lands and individual Tribal allotments), State trust lands, US Forest Service lands, National Park Service lands, US Bureau of Reclamation lands, New Mexico Game and Fish lands, and private property.



Surface Administration

- Tribal trust land
- Navajo allotment land
- Navajo Tribal fee
- BLM
- Private
- US Forest Service
- State trust
- National Park Service
- Bureau of Reclamation
- NM Game and Fish
- Planning area
- Field office boundary
- Navajo Nation Chapter

Figure 1-3
Existing Oil and Gas Leases

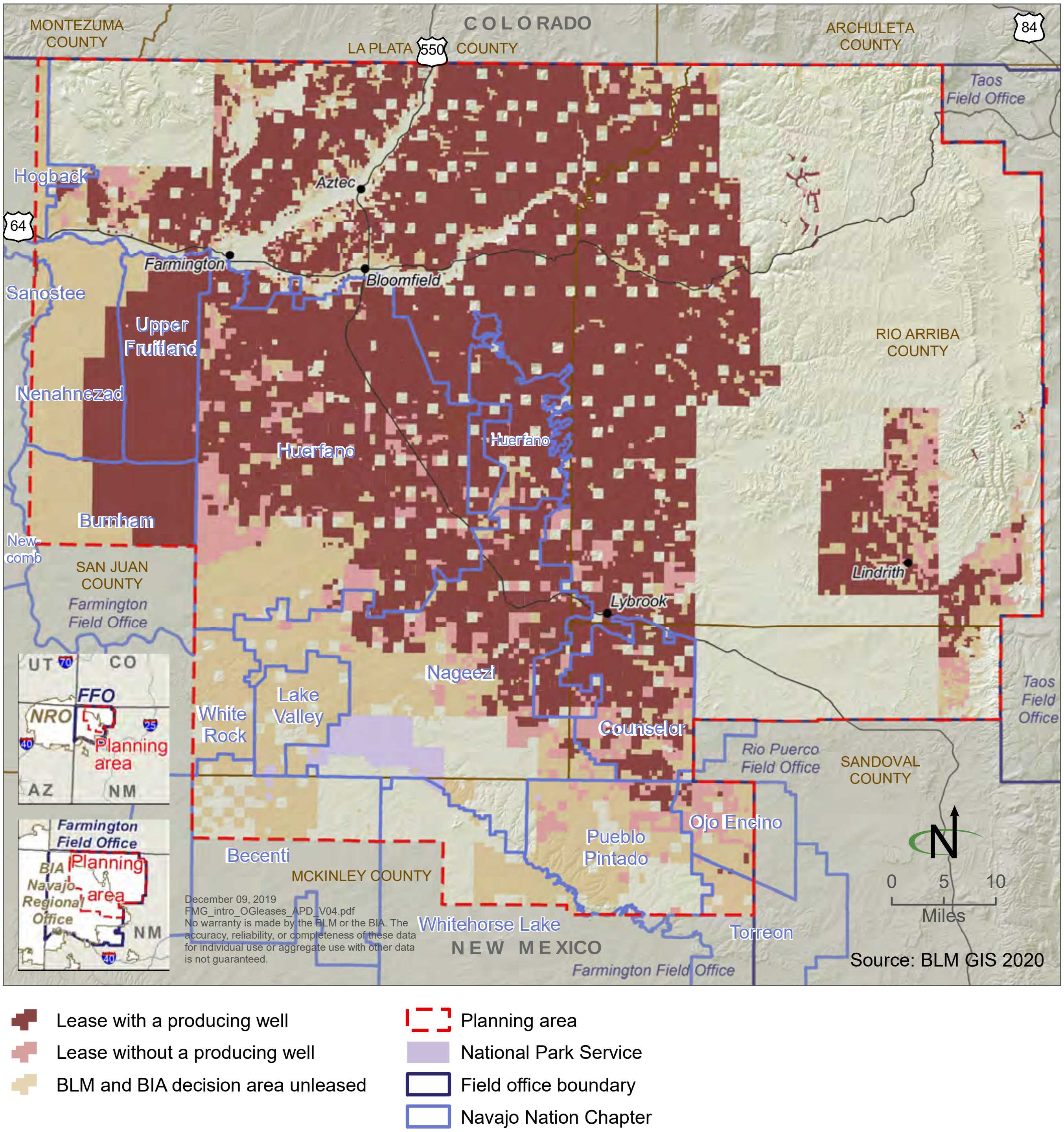


Figure 1-5
BLM Decision Area

The BLM decision area for the RMPA/EIS includes only the surface lands and federal mineral estate within the planning area for which the BLM has authority to make land use and management decisions.

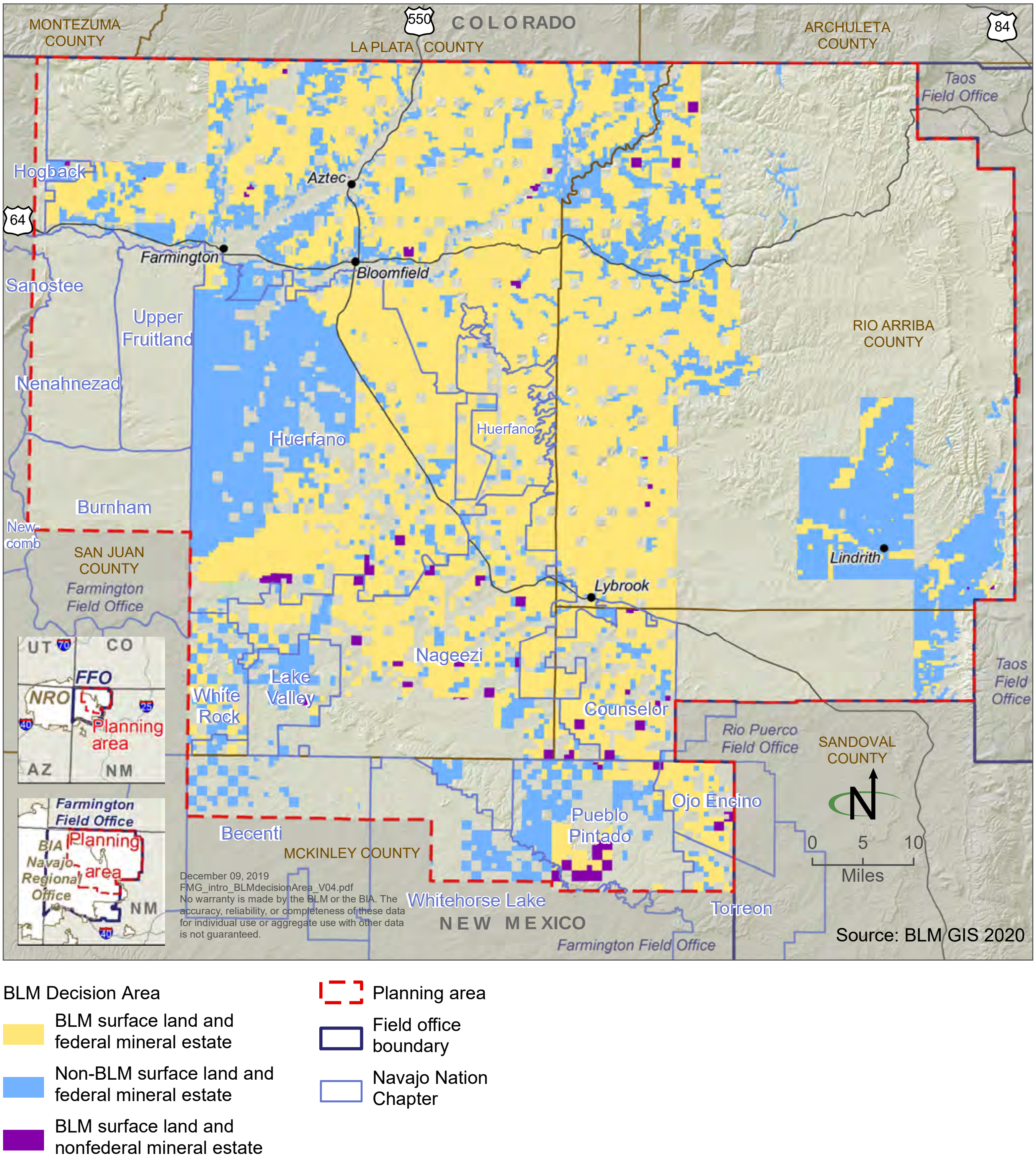
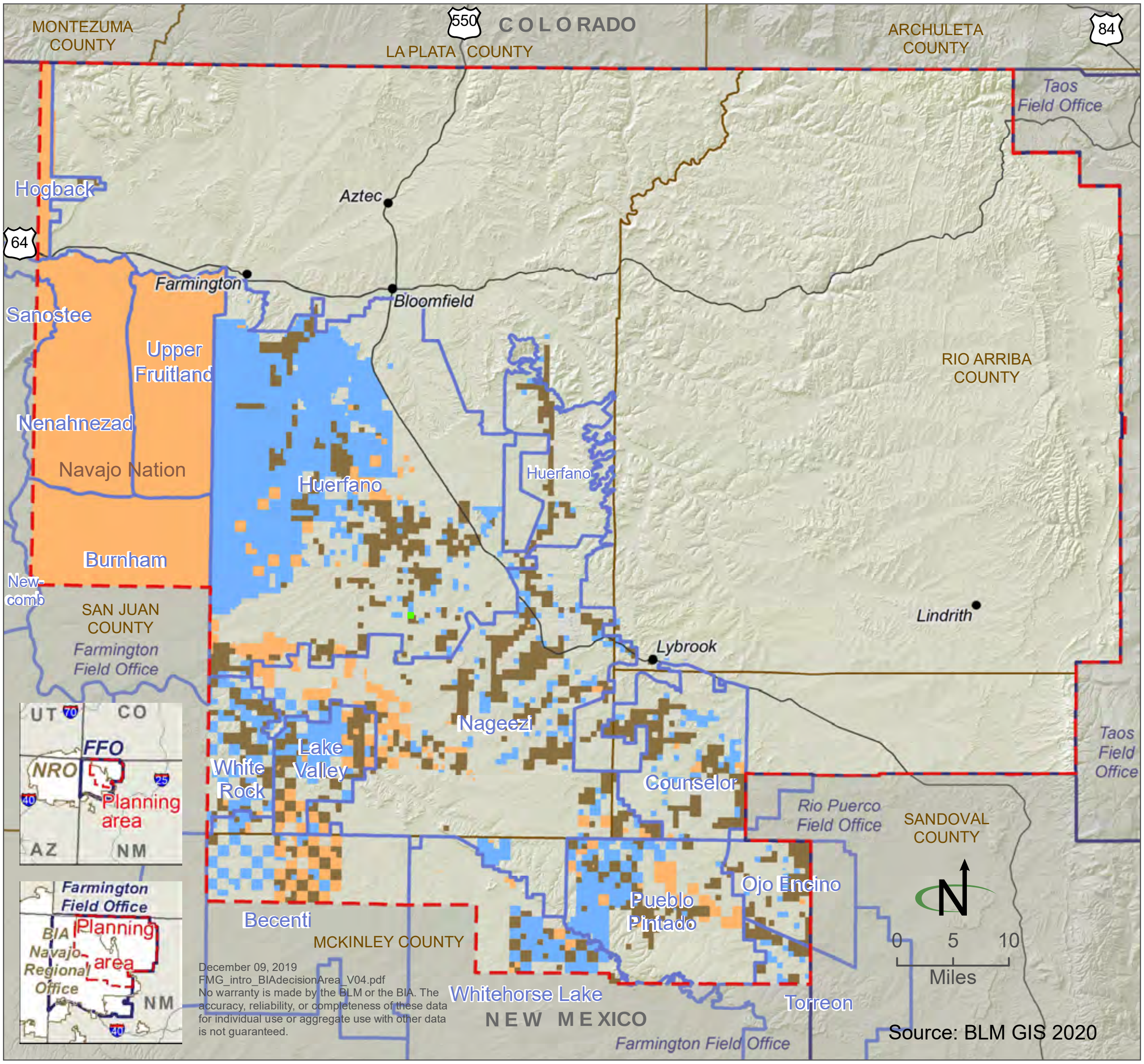


Figure 1-7
BIA Decision Area

The BIA decision area includes the surface lands and subsurface mineral estate in the planning area for which the BIA NRO has authority to make decisions regarding mineral leasing and associated activities. Tribal trust lands of the Jicarilla Apache Nation and the Ute Mountain Ute Tribe and Navajo Tribal fee lands are not part of the BIA decision area.



BIA Decision Area

- Navajo trust surface land and Navajo trust subsurface mineral estate
- Navajo trust surface land and federal mineral estate
- Navajo allotment surface land and Navajo allotment subsurface mineral estate
- Navajo trust surface land and Navajo allotment subsurface mineral estate

- Planning area
- Field office boundary
- Navajo Nation Chapter

Figure 2-1
BLM Alternative A: Vegetation Treatments

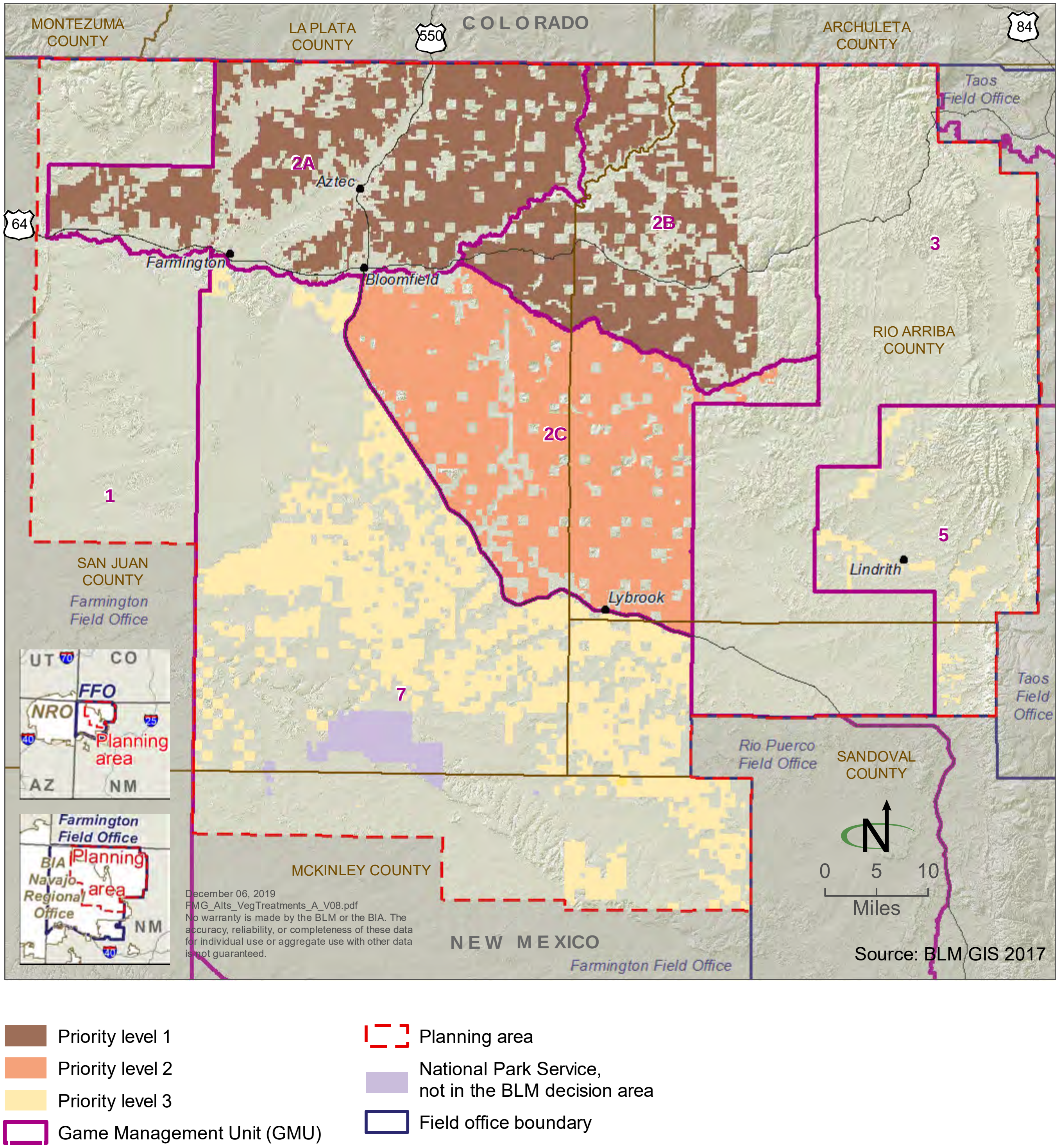
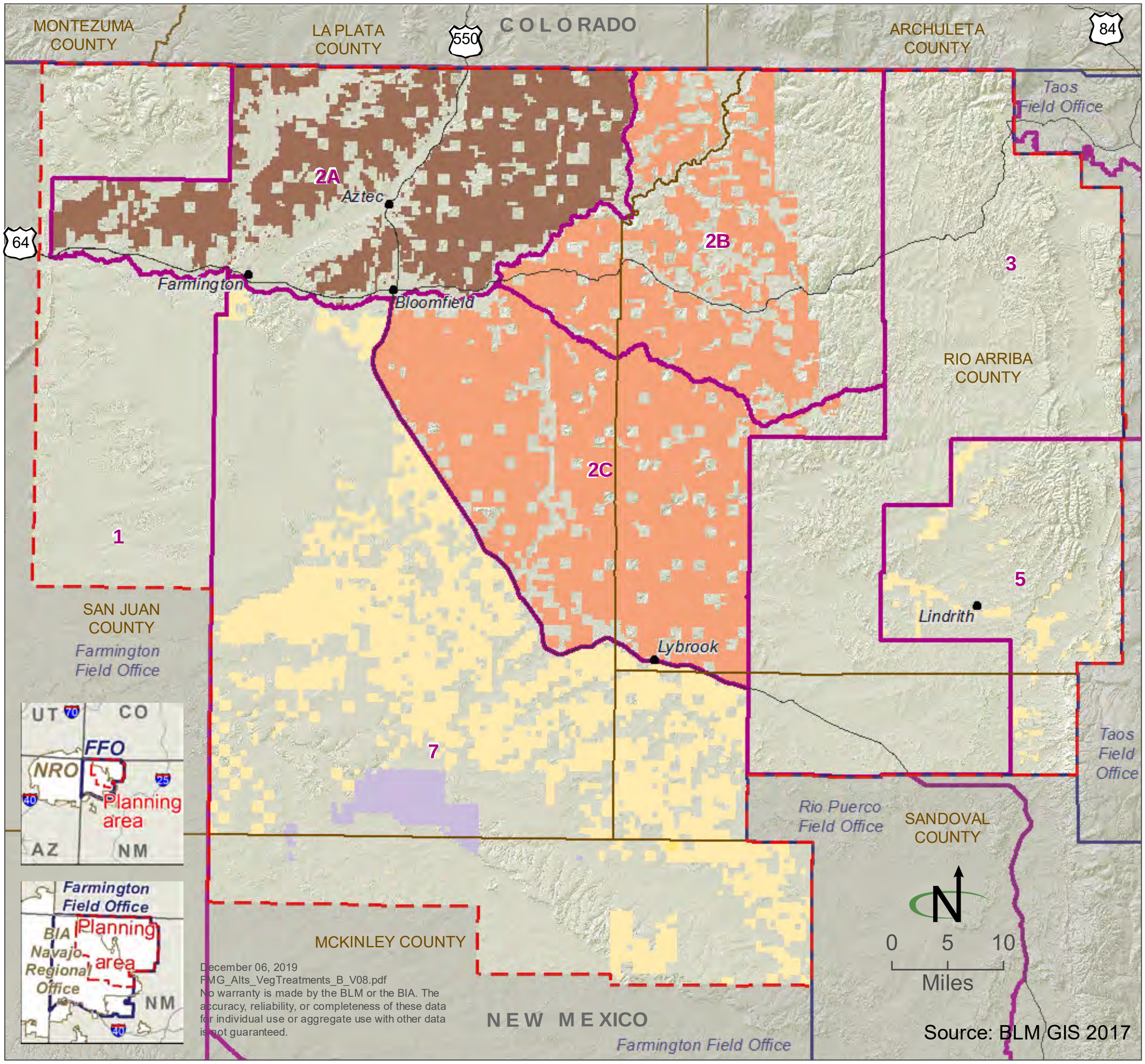
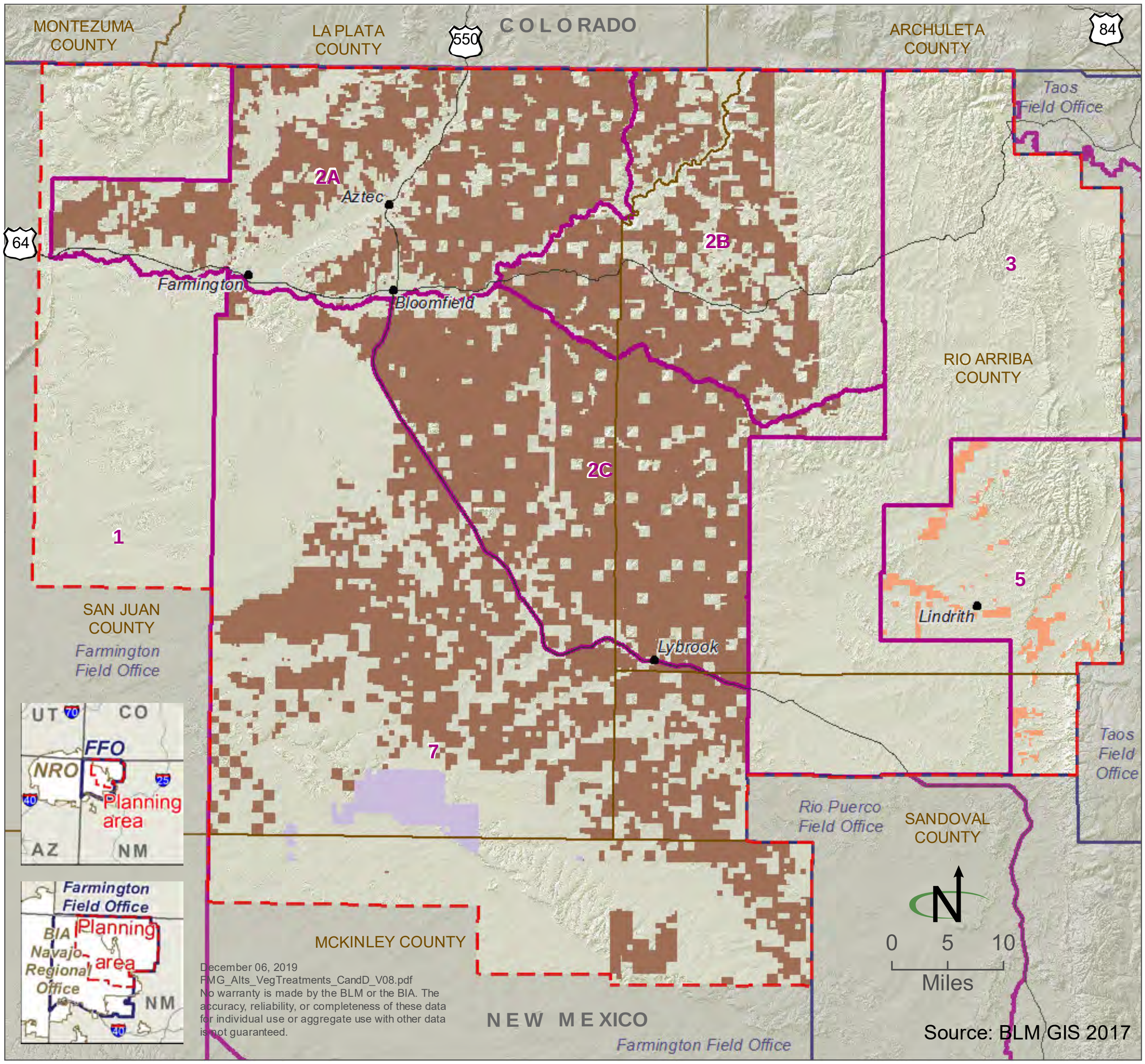


Figure 2-2
BLM Alternative B:
Vegetation Treatments



- Priority level 1
- Priority level 2
- Priority level 3
- Game Management Unit (GMU)
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-3
BLM Alternatives C and D: Vegetation Treatments



Priority level 1
Priority level 2
Priority level 3
Game Management Unit (GMU)
Planning area
National Park Service, not in the BLM decision area
Field office boundary

Figure 2-4
BLM Alternative A:
Plant Conservation Areas

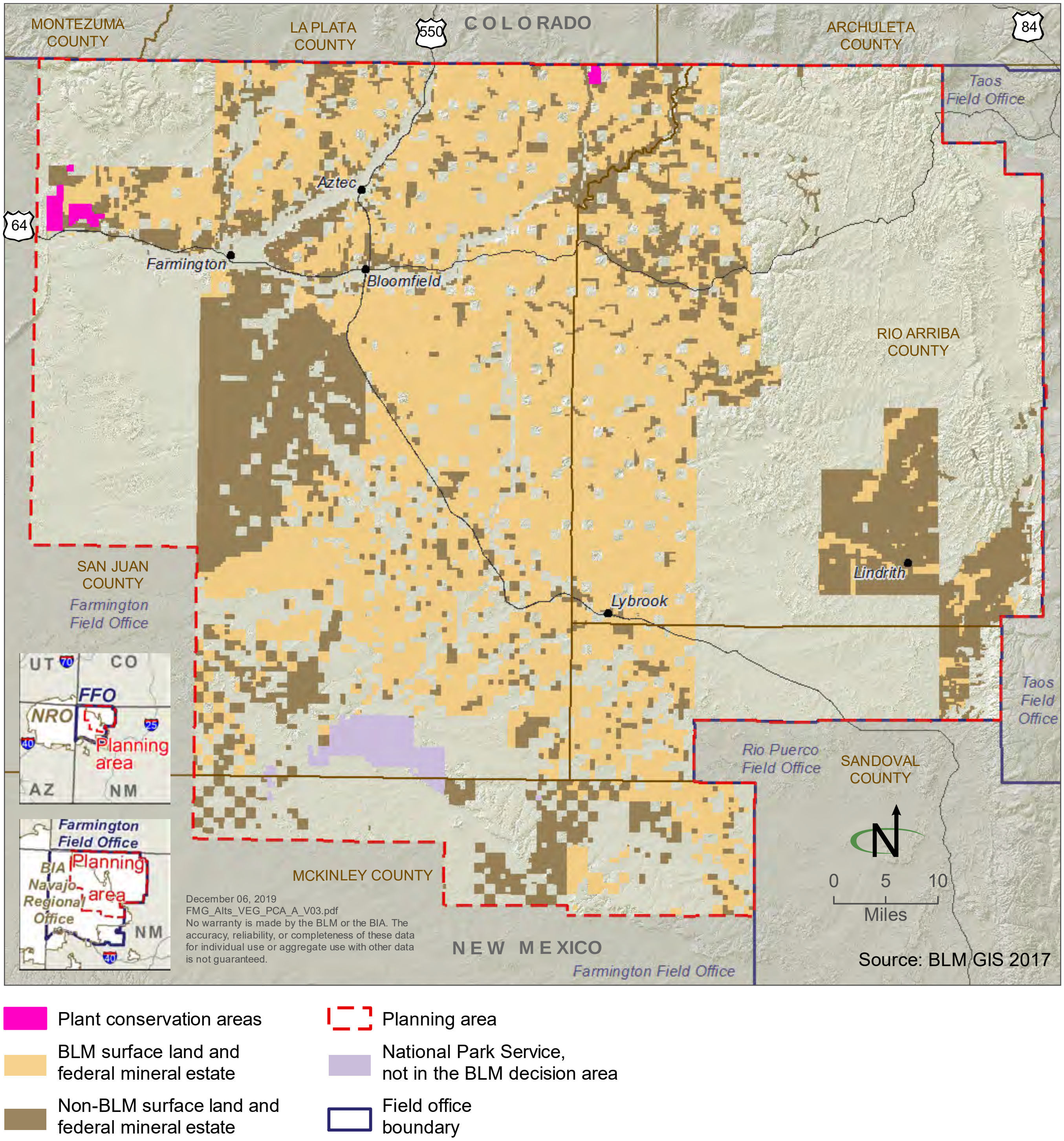
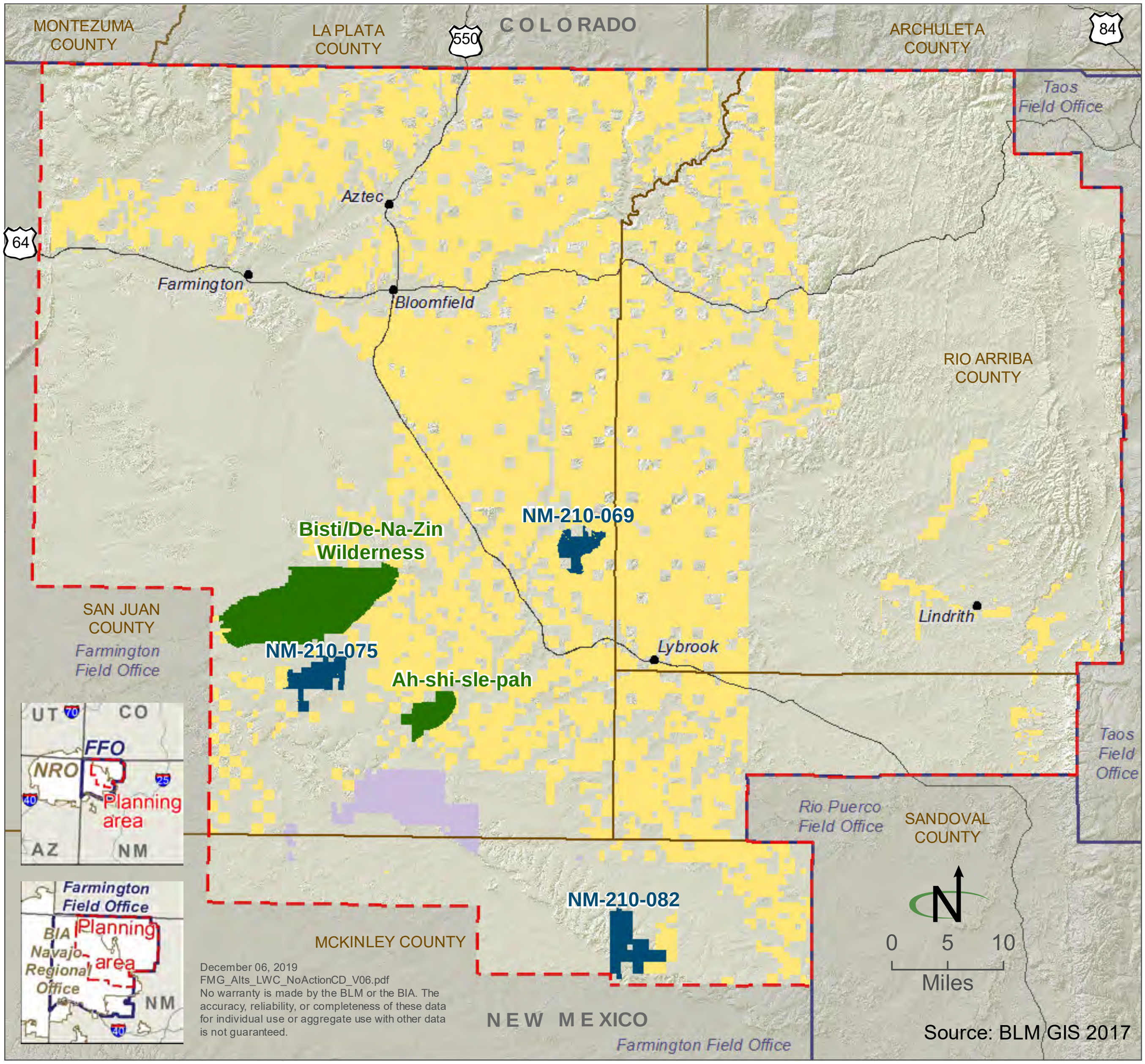


Figure 2-5
BLM Alternatives No Action, C, and D: Lands with Wilderness Characteristics



Lands managed to emphasize other multiple uses as a priority over protecting wilderness characteristics

Wilderness area

BLM surface land

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-6
BLM Alternatives A and B: Lands with Wilderness Characteristics

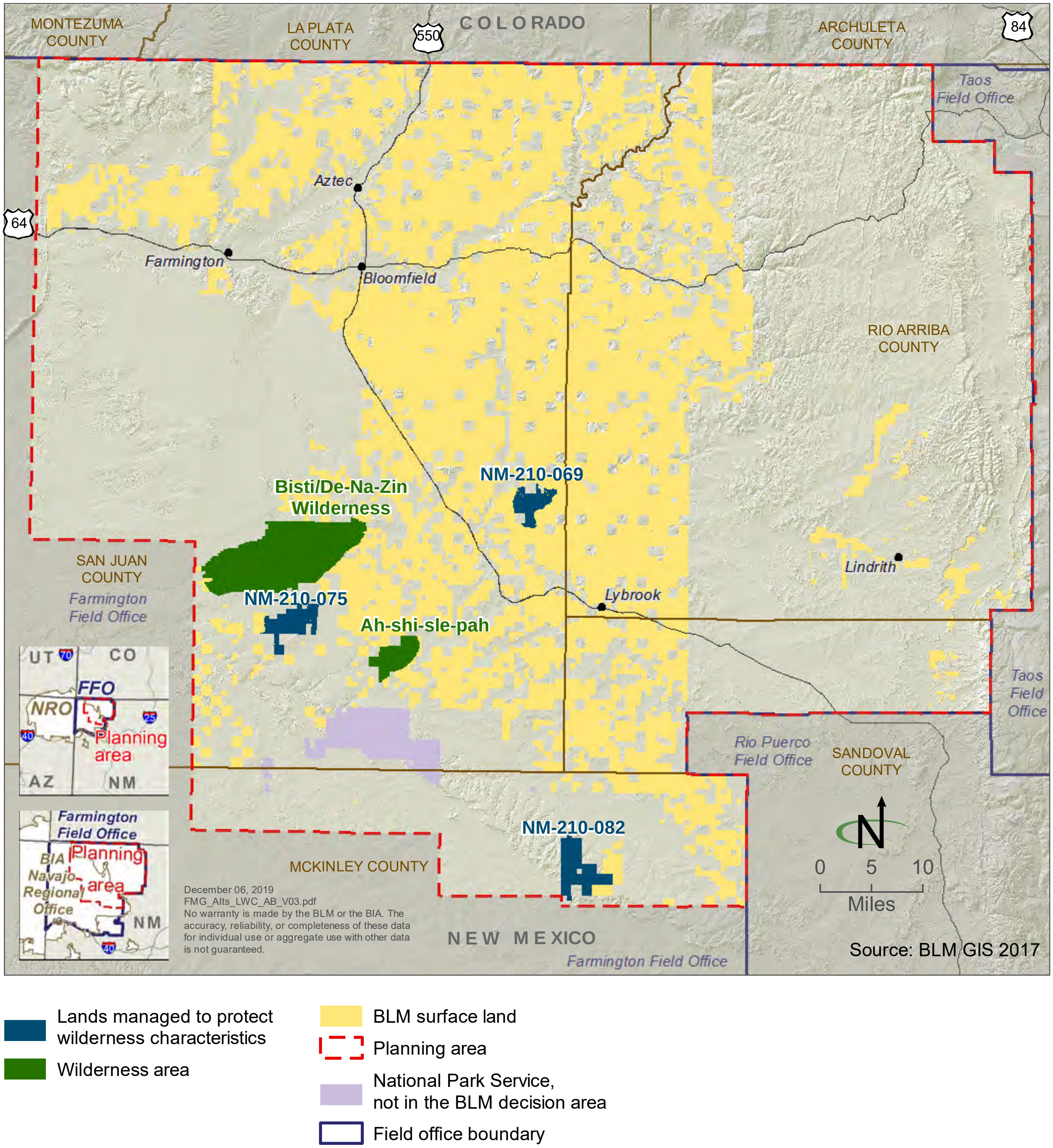


Figure 2-7
BLM No Action Alternative: Fluid Mineral Leasing

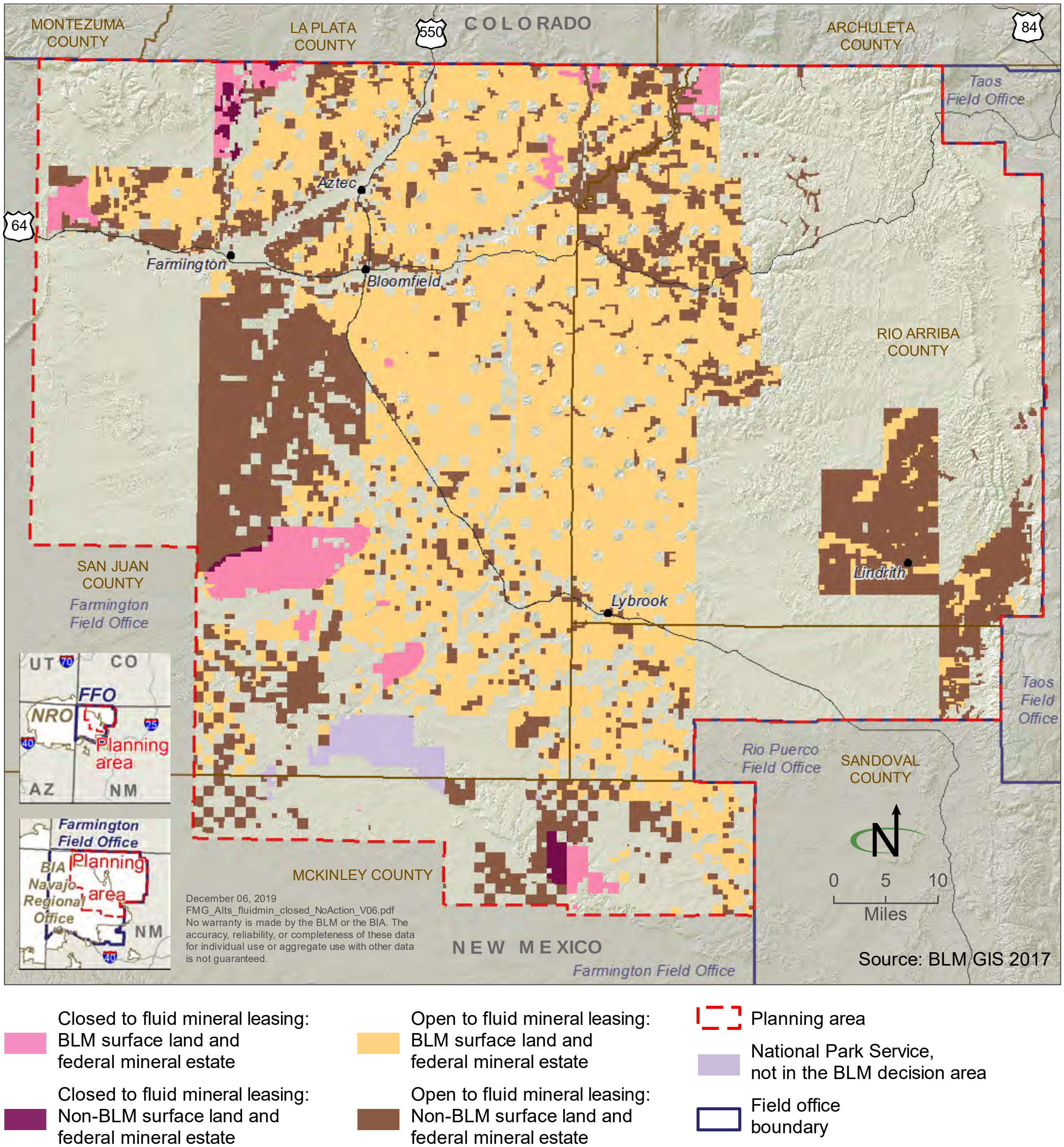
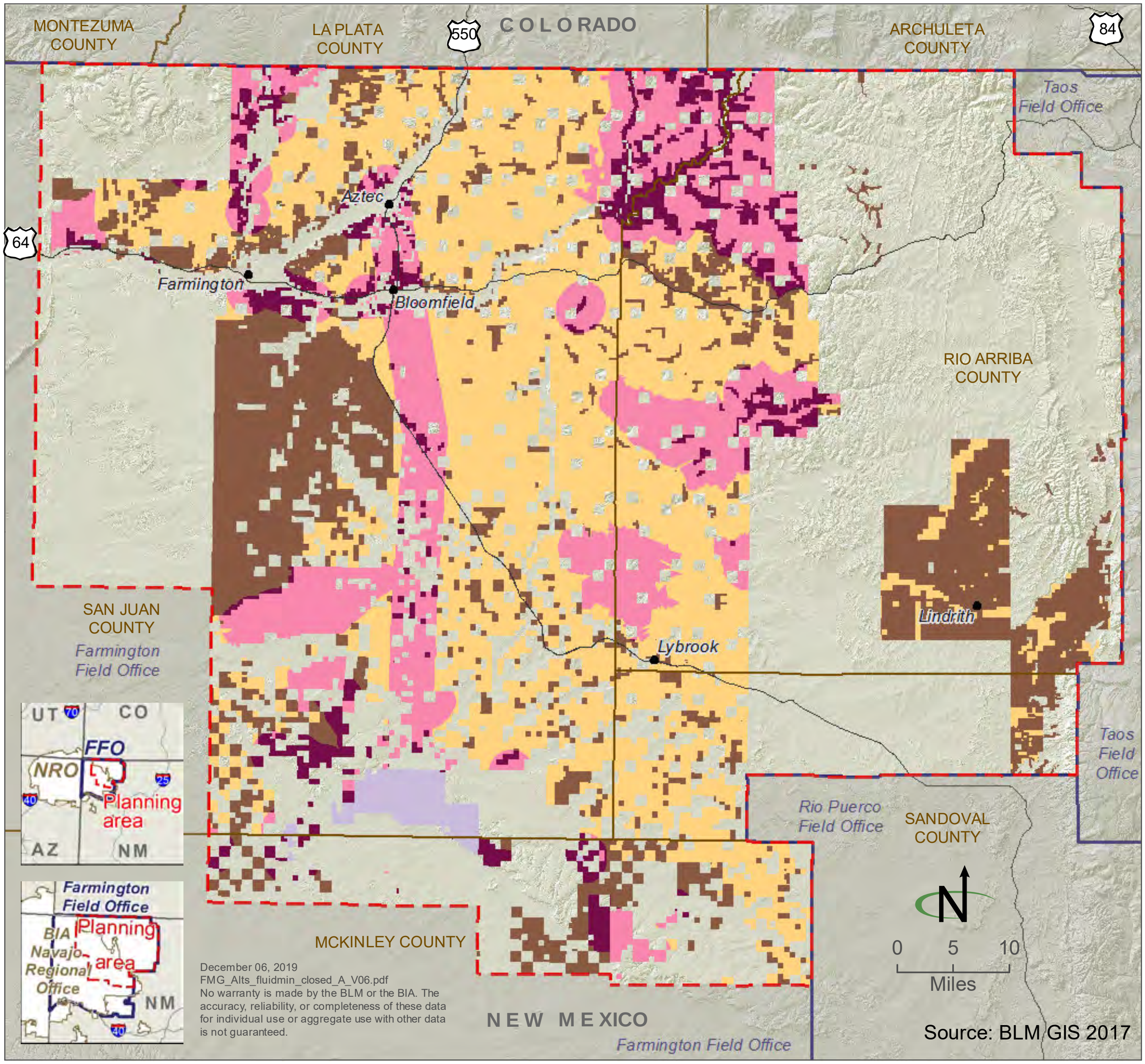


Figure 2-8
BLM Alternative A:
Fluid Mineral Leasing



Closed to fluid mineral leasing: BLM surface land and federal mineral estate

Closed to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Open to fluid mineral leasing: BLM surface land and federal mineral estate

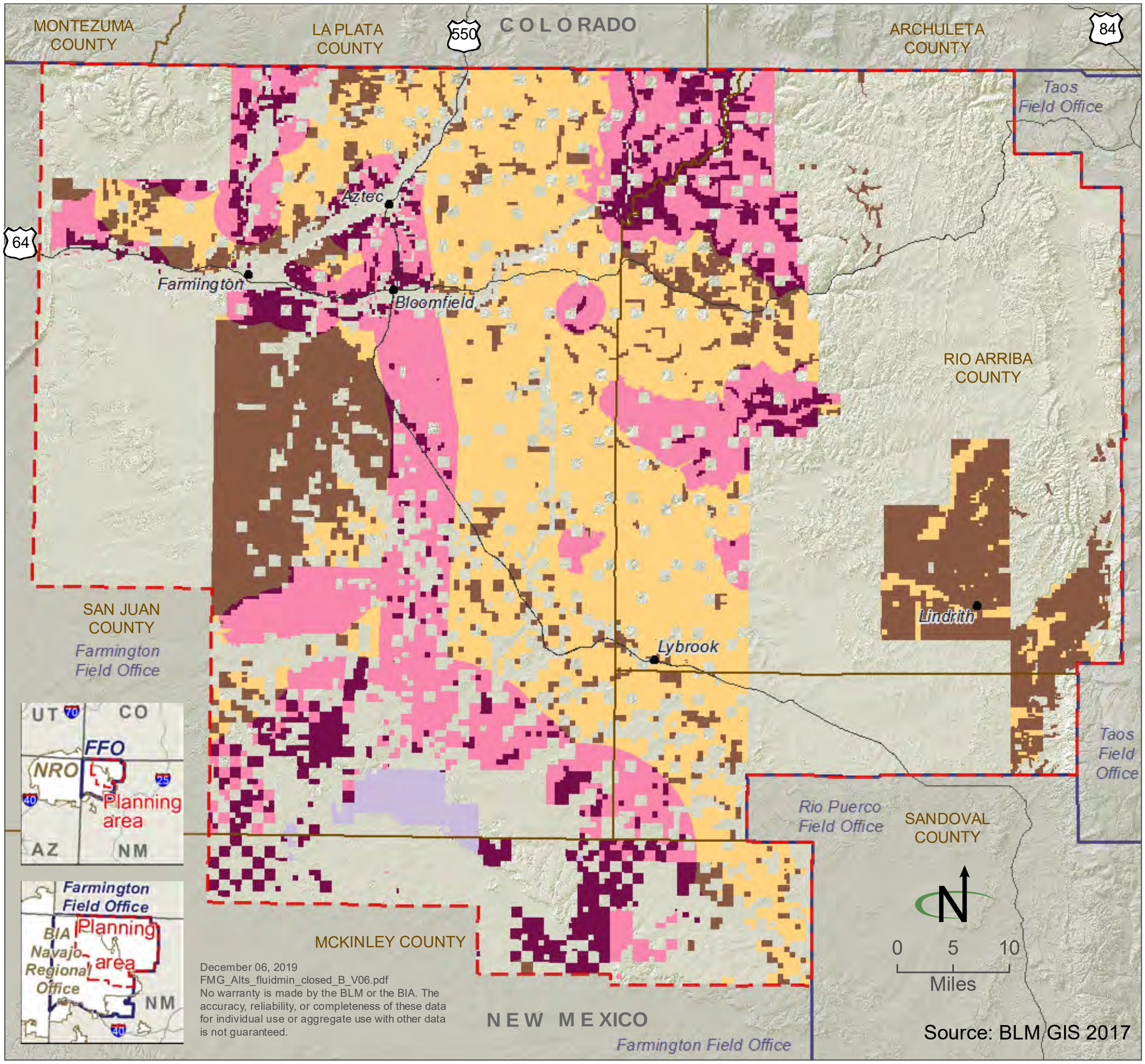
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-9
BLM Sub-Alternative B1:
Fluid Mineral Leasing



Closed to fluid mineral leasing: BLM surface land and federal mineral estate

Closed to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Open to fluid mineral leasing: BLM surface land and federal mineral estate

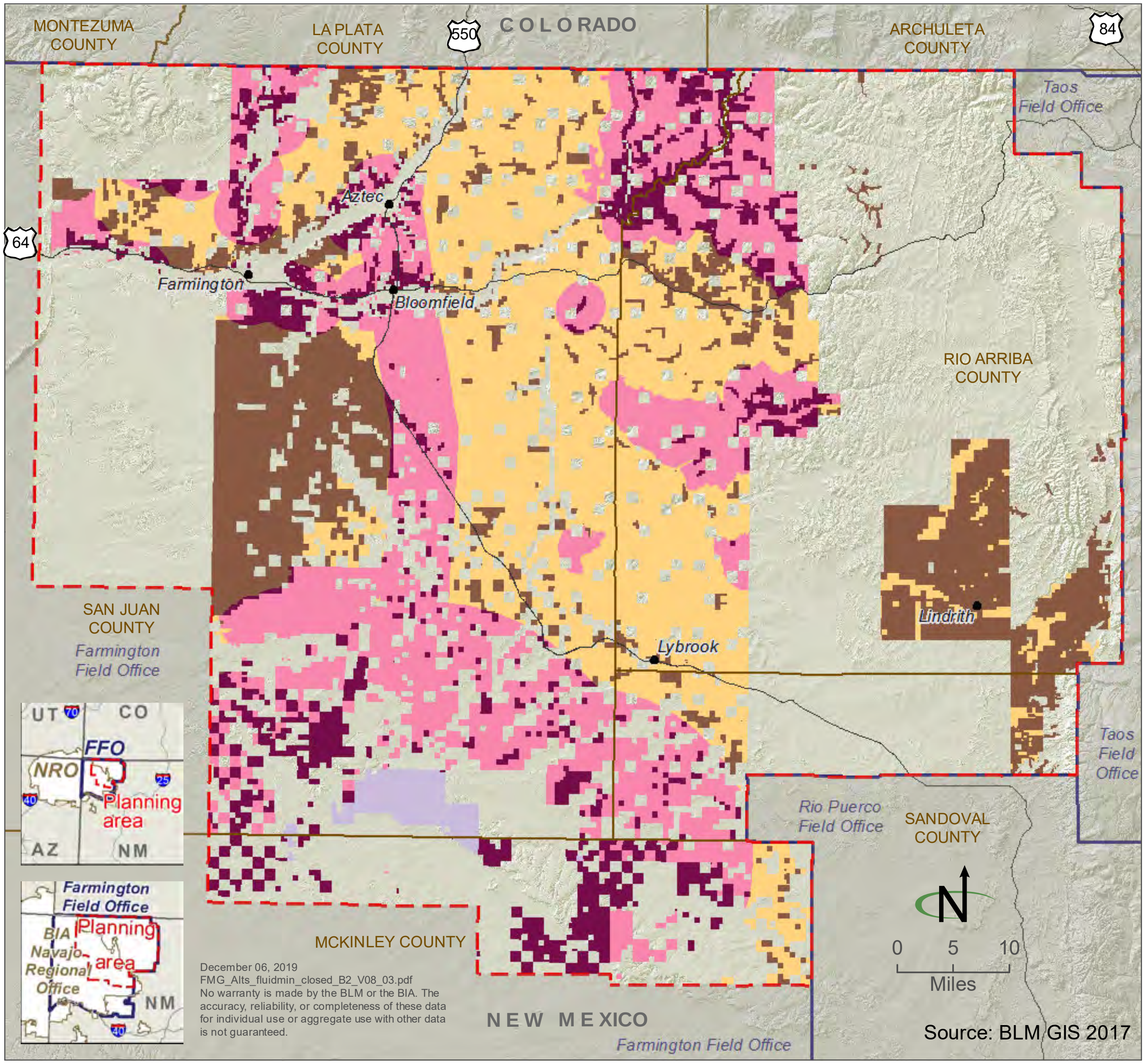
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-10
BLM Sub-Alternative B2:
Fluid Mineral Leasing



Closed to fluid mineral leasing: BLM surface land and federal mineral estate

Closed to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Open to fluid mineral leasing: BLM surface land and federal mineral estate

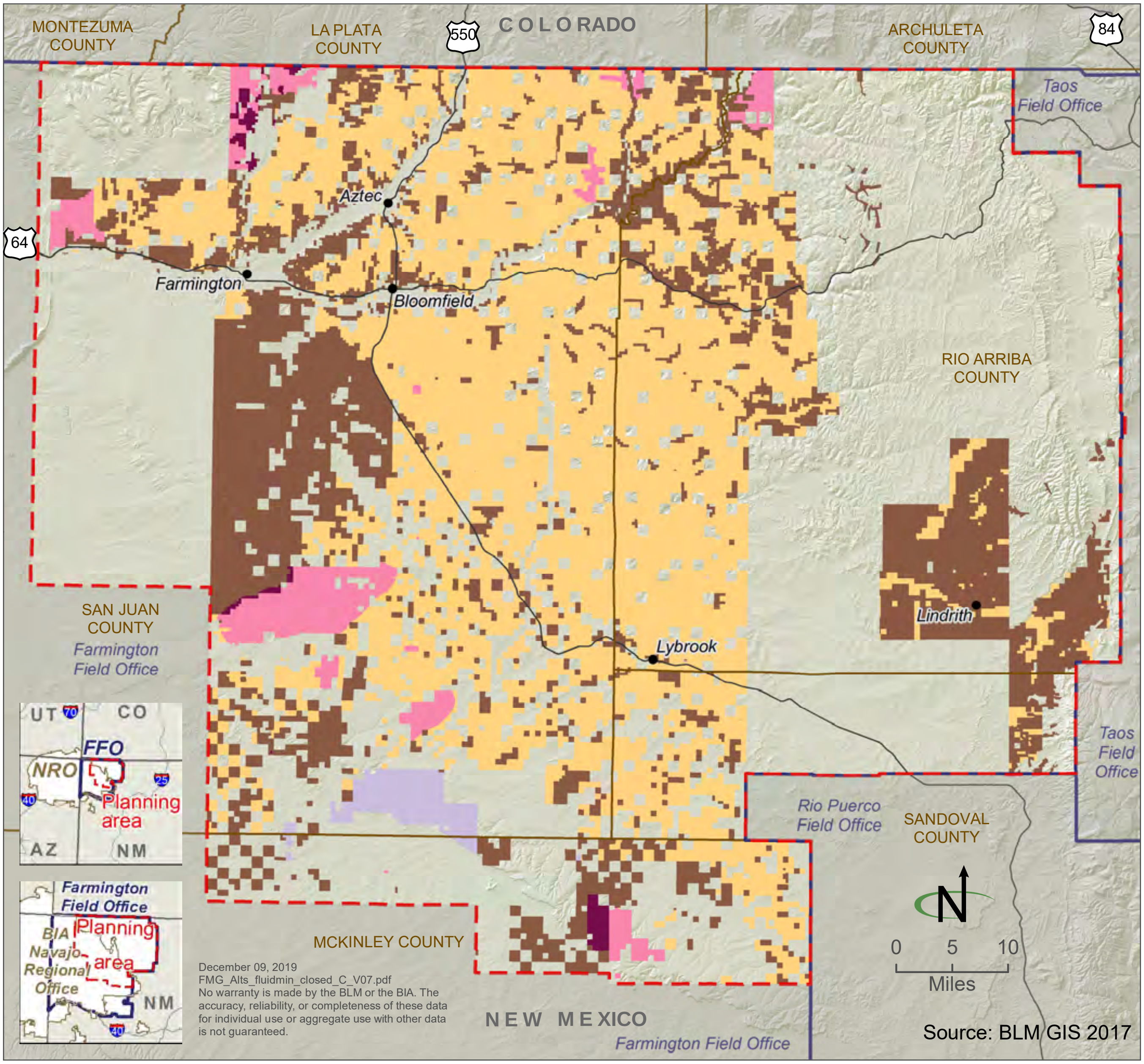
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-11
BLM Sub-Alternatives C1-C5:
Fluid Mineral Leasing



Closed to fluid mineral leasing: BLM surface land and federal mineral estate

Closed to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Open to fluid mineral leasing: BLM surface land and federal mineral estate

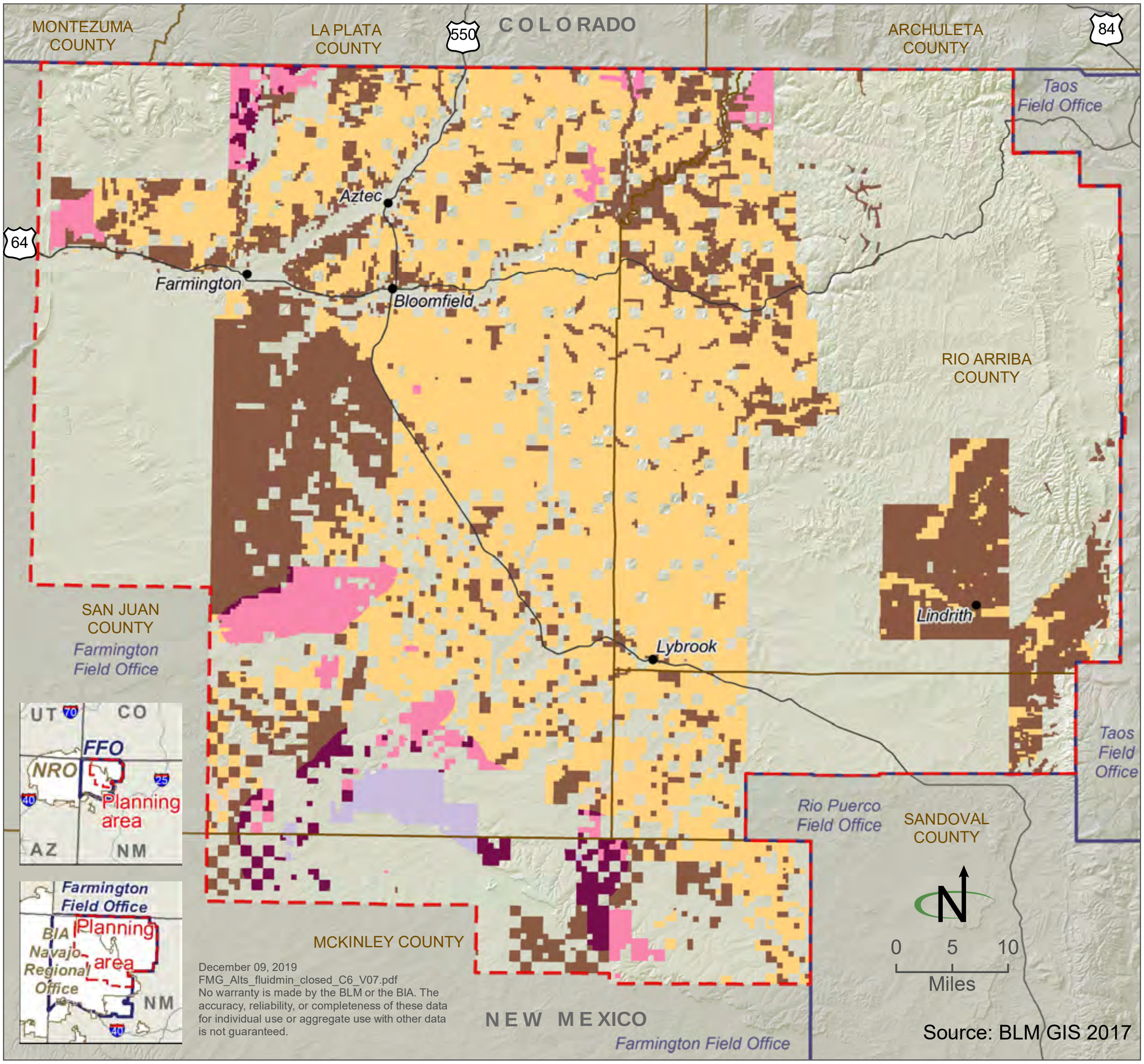
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-12
BLM Sub-Alternative C6: Fluid Mineral Leasing



Closed to fluid mineral leasing: BLM surface land and federal mineral estate

Closed to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Open to fluid mineral leasing: BLM surface land and federal mineral estate

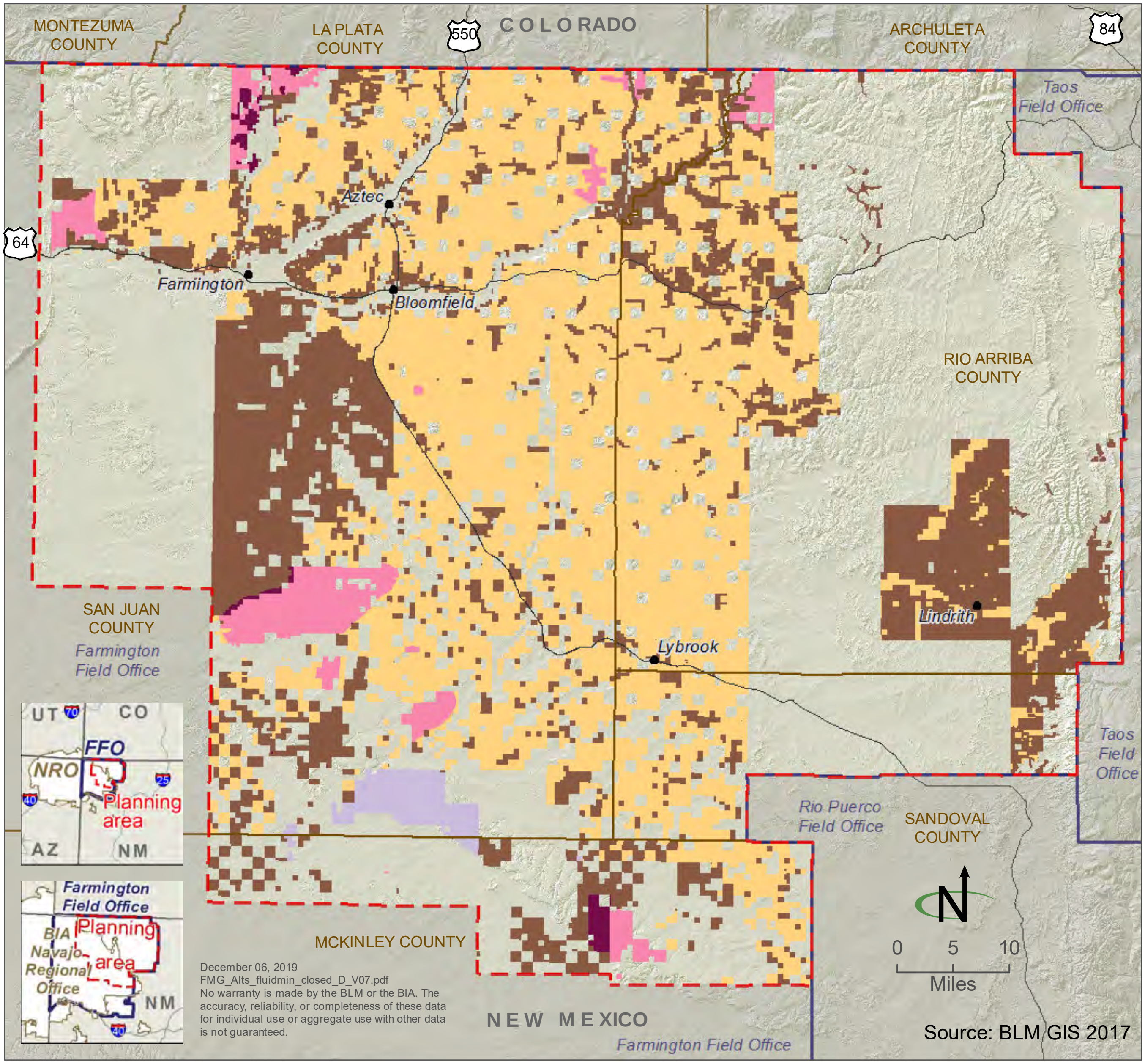
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

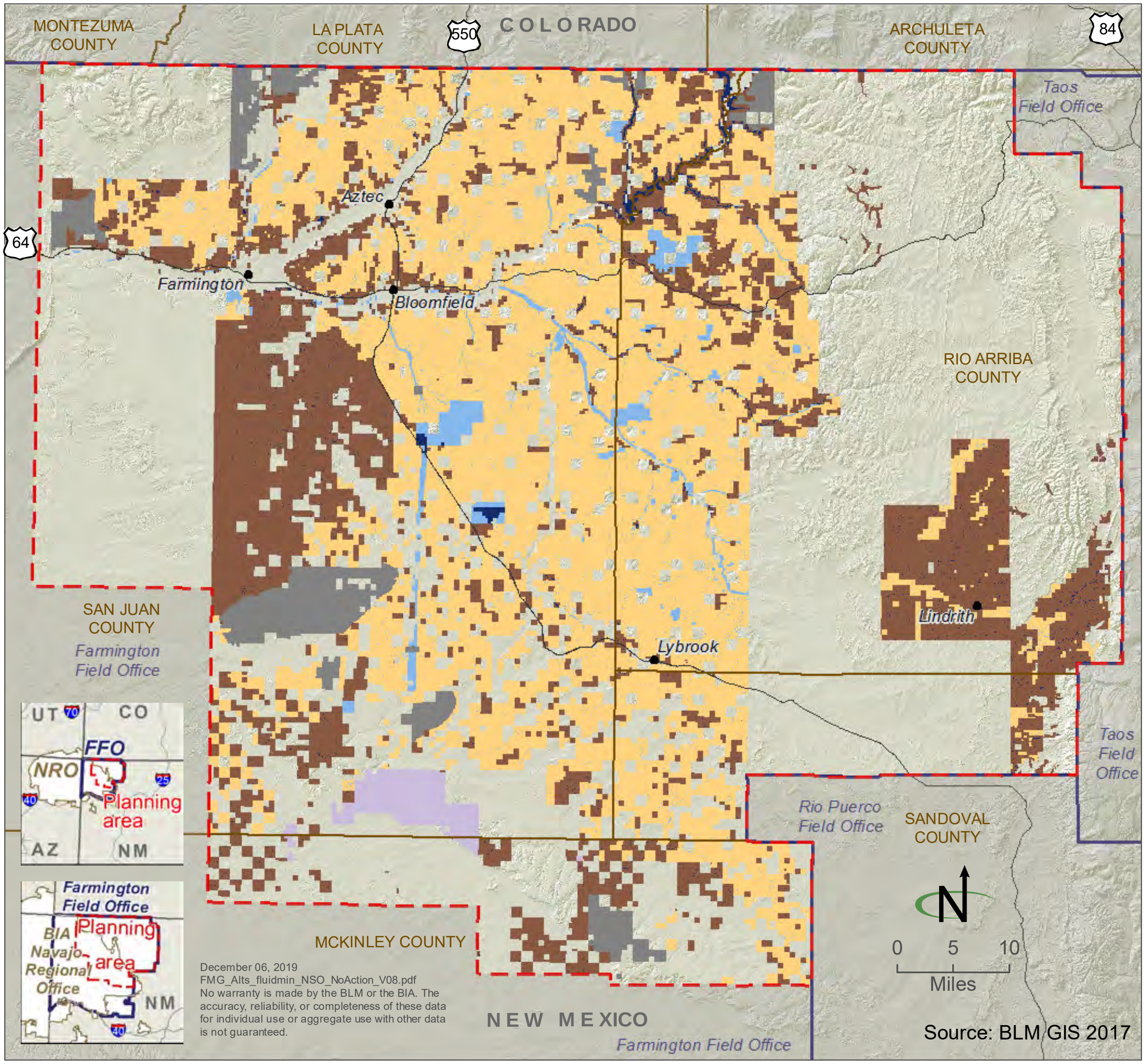
Field office boundary

Figure 2-13
BLM Alternative D:
Fluid Mineral Leasing



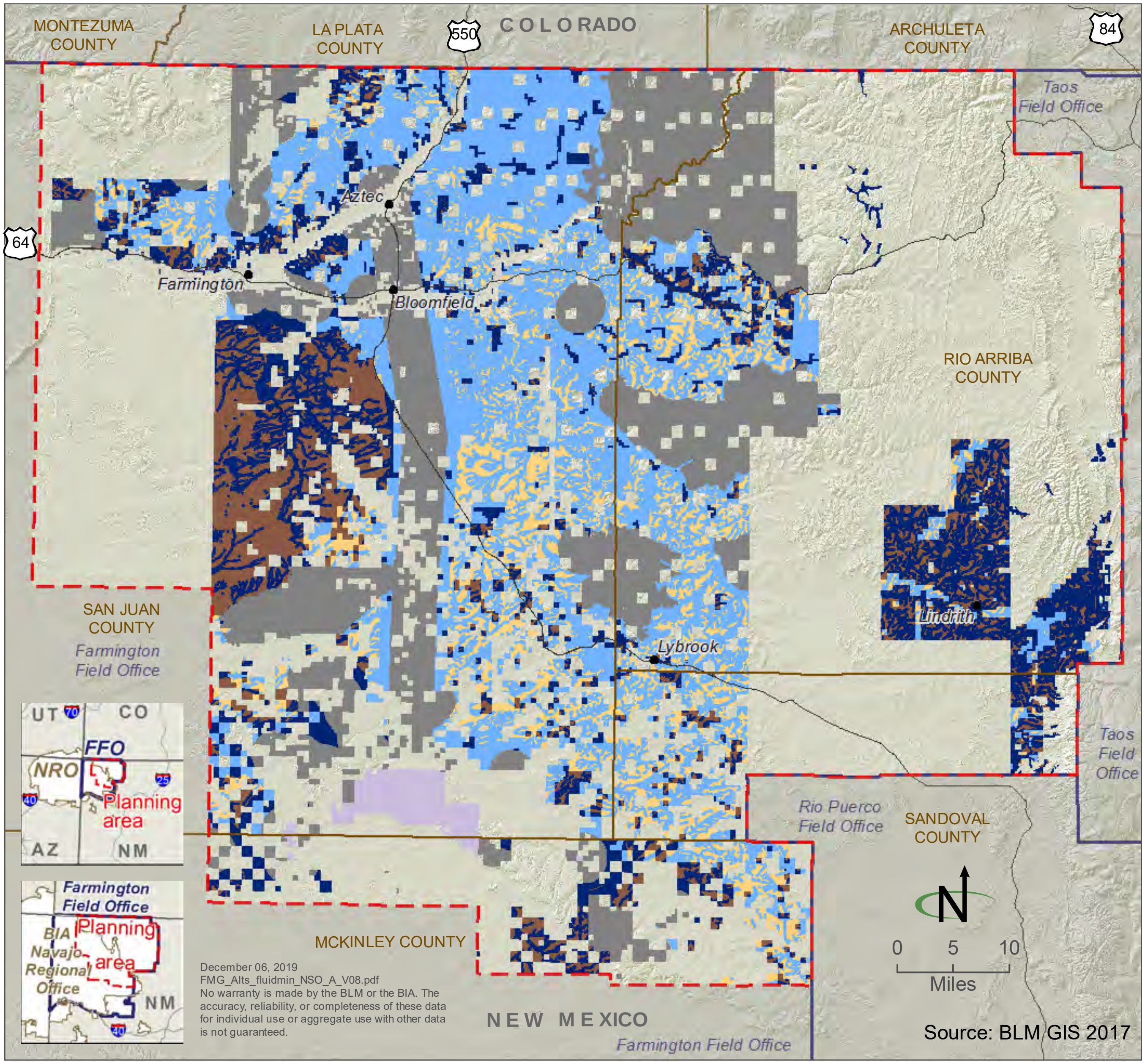
- Closed to fluid mineral leasing: BLM surface land and federal mineral estate
- Closed to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-14
BLM No Action Alternative:
No Surface Occupancy for Fluid Mineral Leasing



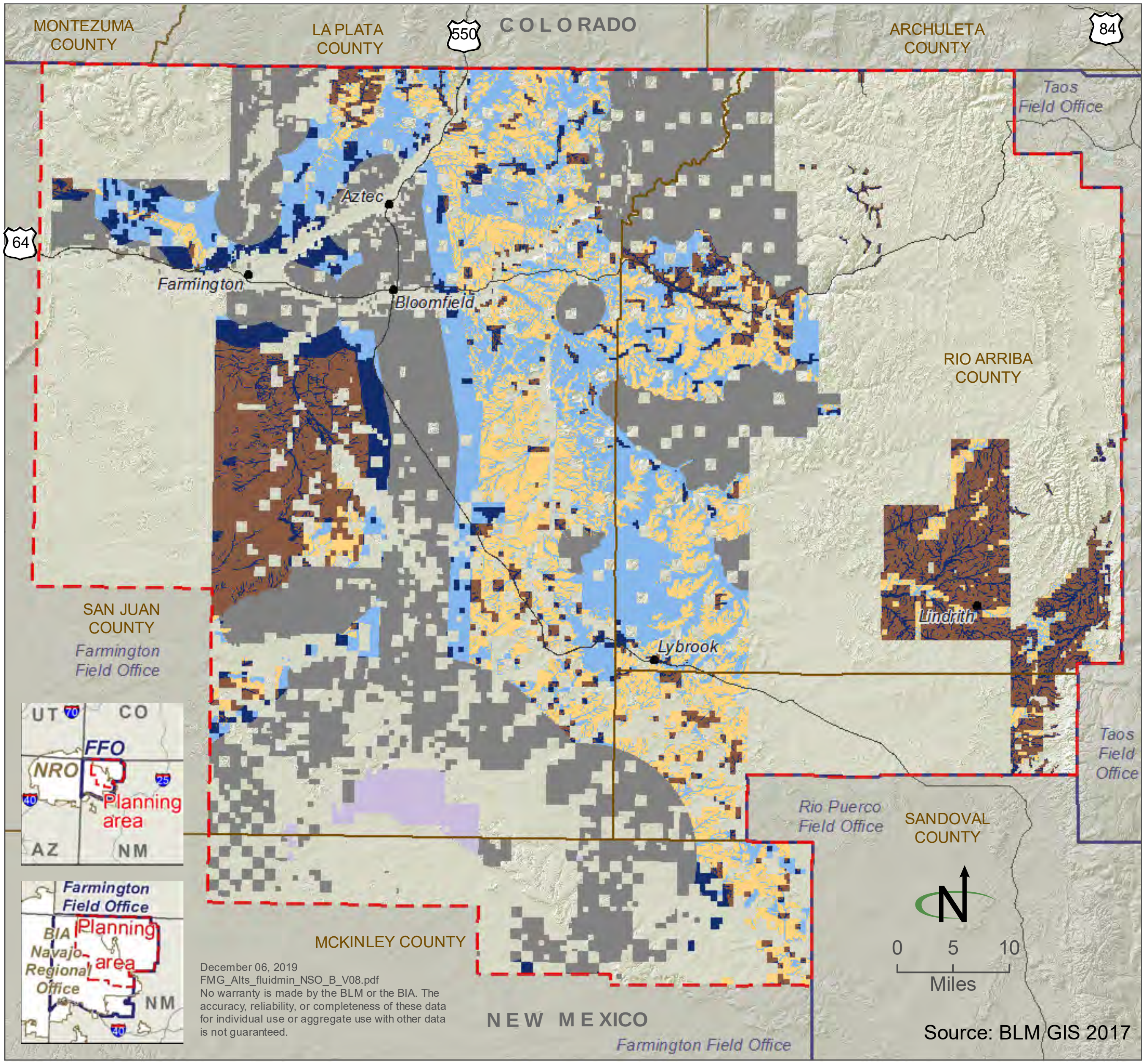
- Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate
- Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-15
BLM Alternative A:
No Surface Occupancy for Fluid Mineral Leasing



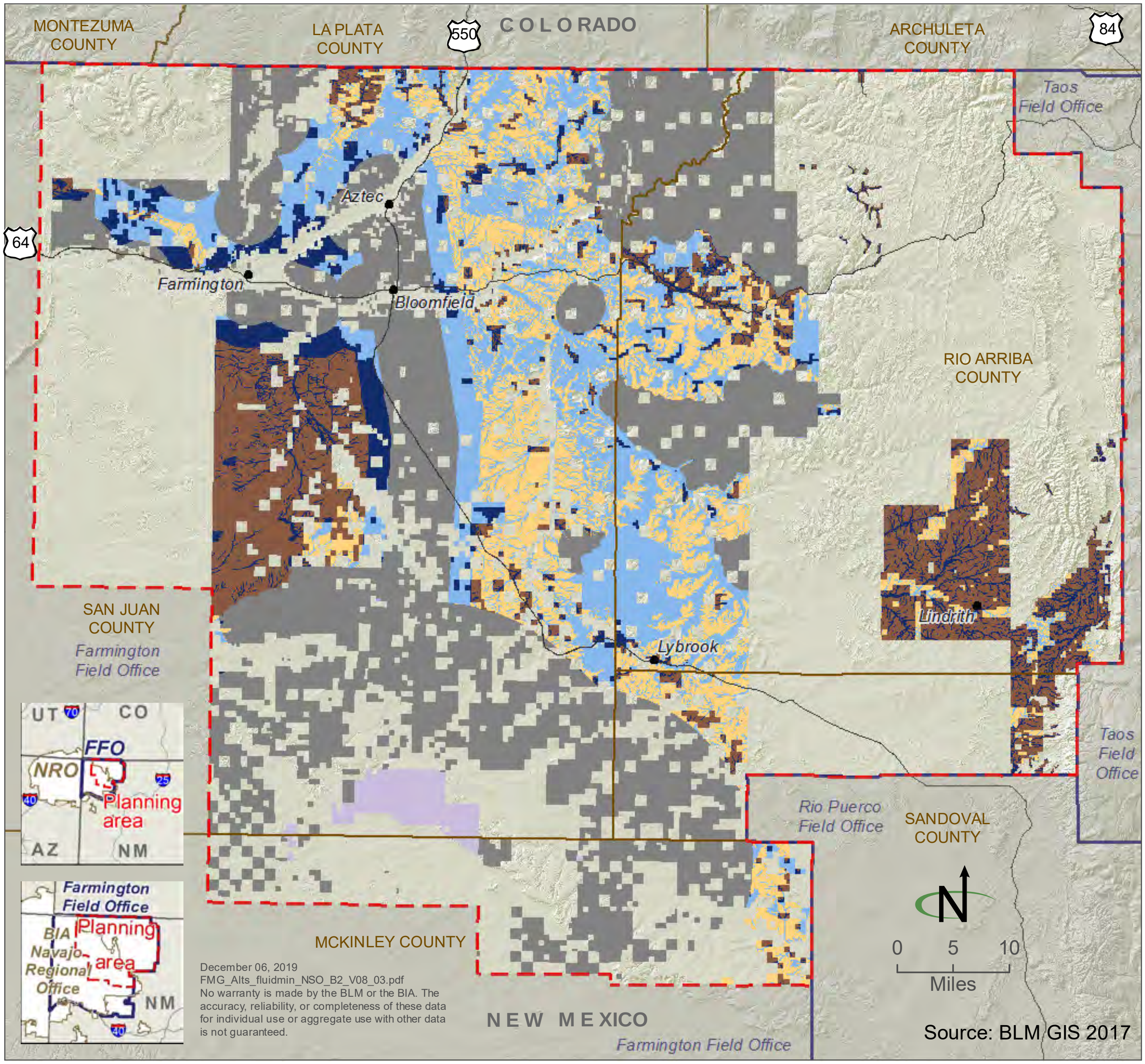
- Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate
- Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-16
BLM Sub-Alternative B1:
No Surface Occupancy for Fluid Mineral Leasing



- Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate
- Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-17
BLM Sub-Alternative B2:
No Surface Occupancy for Fluid Mineral Leasing



Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate

Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate

Closed to fluid mineral leasing

Open to fluid mineral leasing: BLM surface land and federal mineral estate

Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

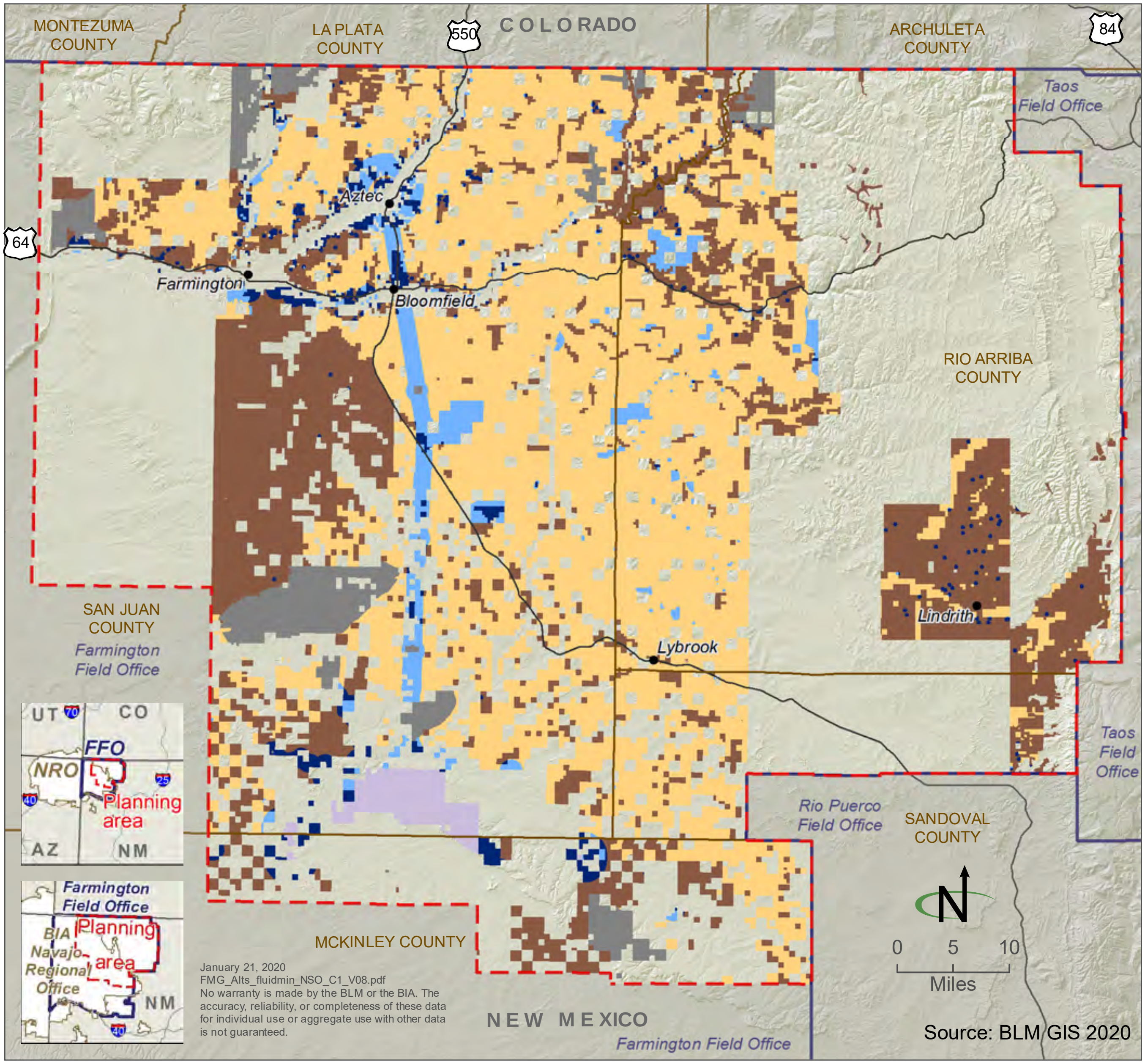
Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-18

BLM Alternative C1:
No Surface Occupancy for Fluid Mineral Leasing



Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate

Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate

Closed to fluid mineral leasing

Open to fluid mineral leasing: BLM surface land and federal mineral estate

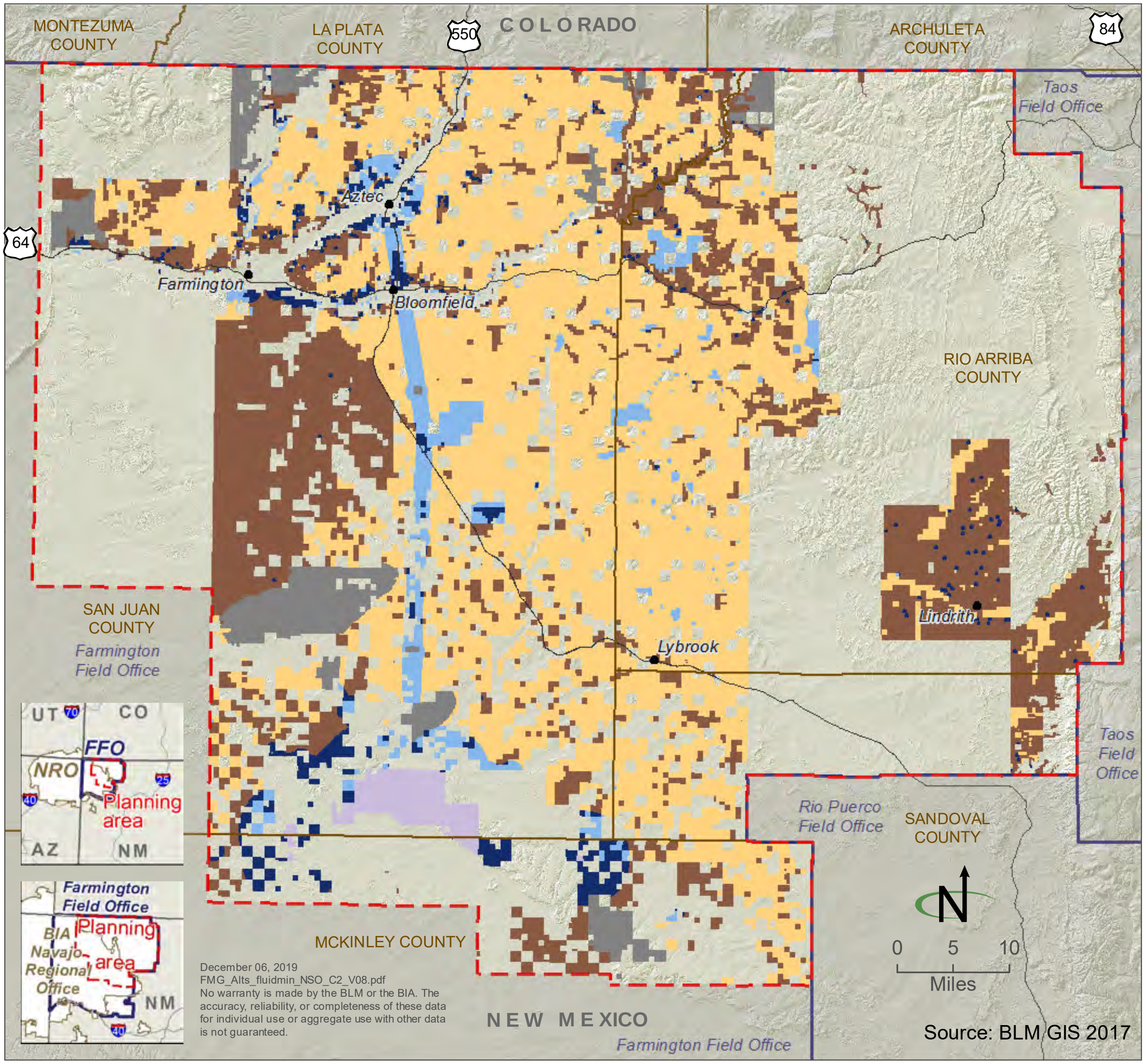
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-19
BLM Alternative C2:
No Surface Occupancy for Fluid Mineral Leasing



Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate

Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate

Closed to fluid mineral leasing

Open to fluid mineral leasing: BLM surface land and federal mineral estate

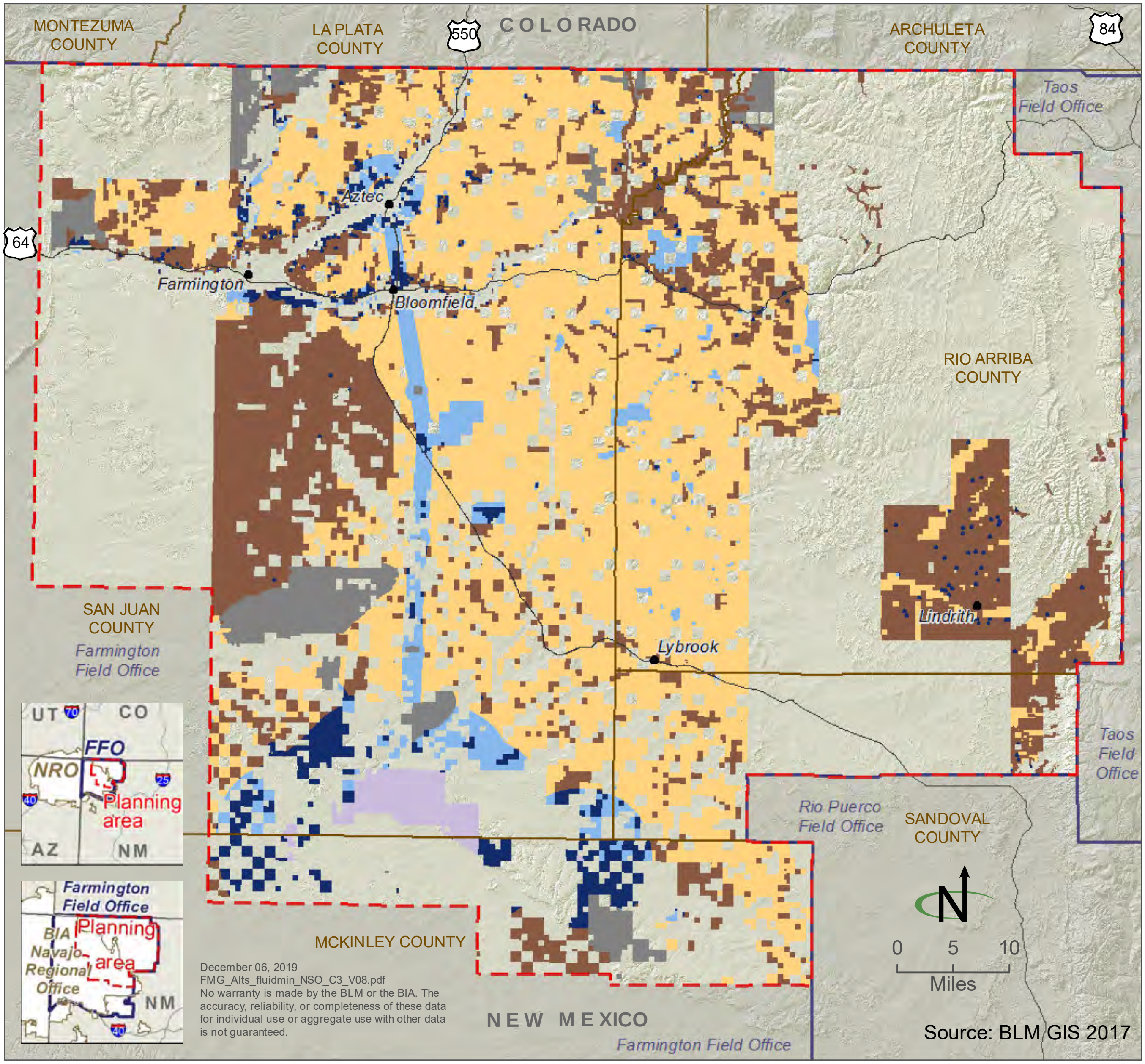
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

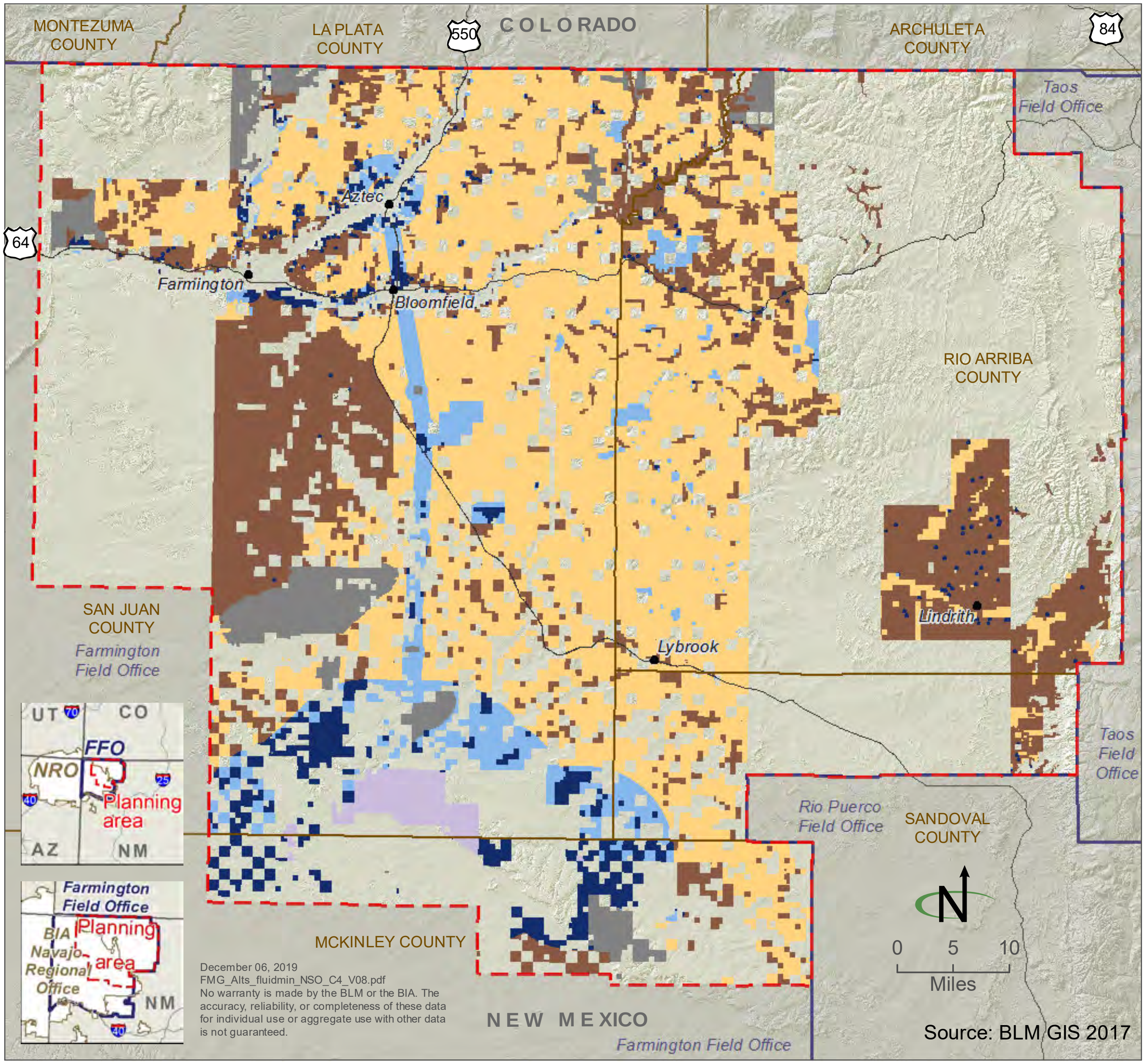
Field office boundary

Figure 2-20
BLM Alternative C3:
No Surface Occupancy for Fluid Mineral Leasing



- Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate
- Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-21
BLM Alternative C4:
No Surface Occupancy for Fluid Mineral Leasing



Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate

Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate

Closed to fluid mineral leasing

Open to fluid mineral leasing: BLM surface land and federal mineral estate

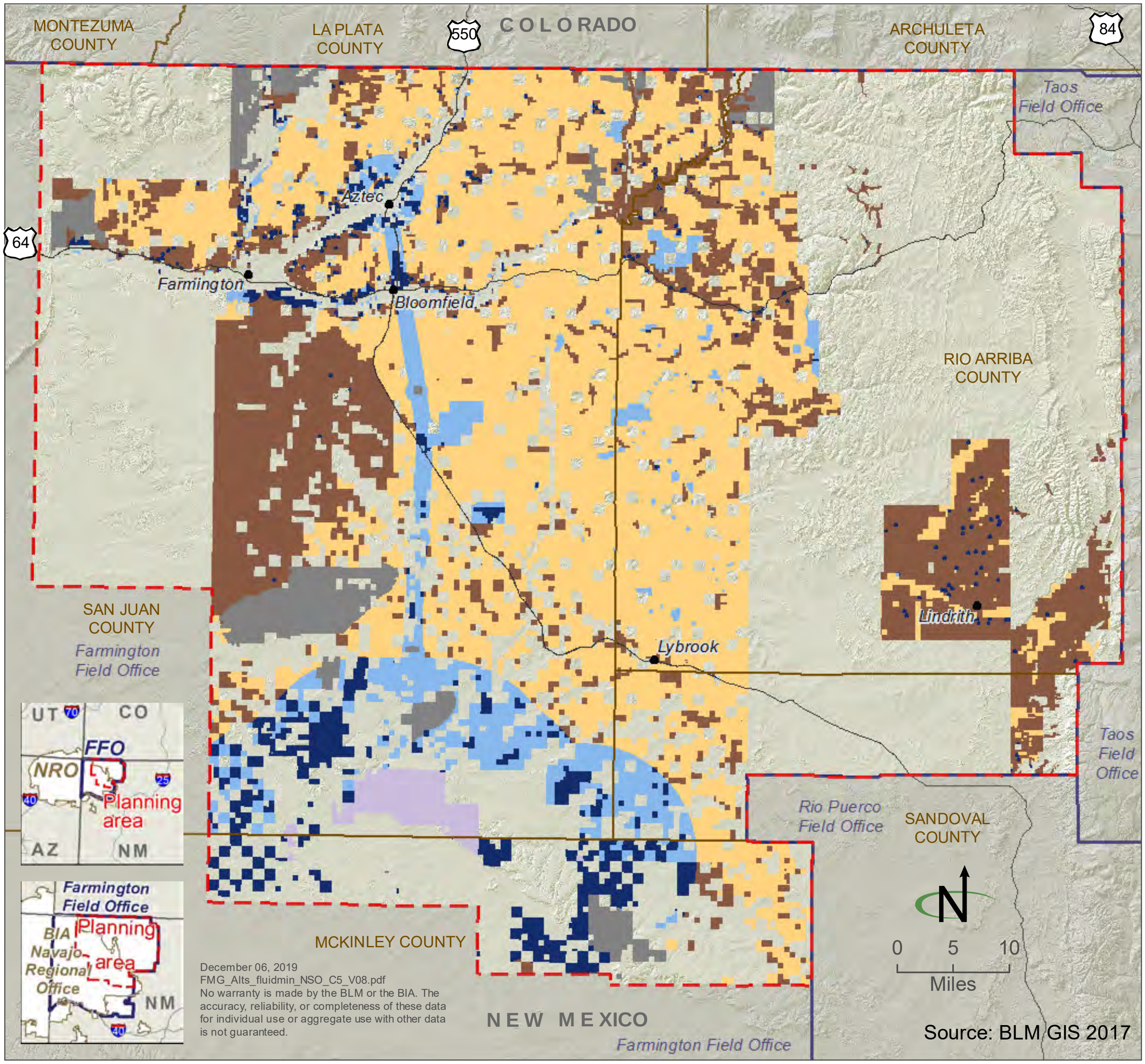
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

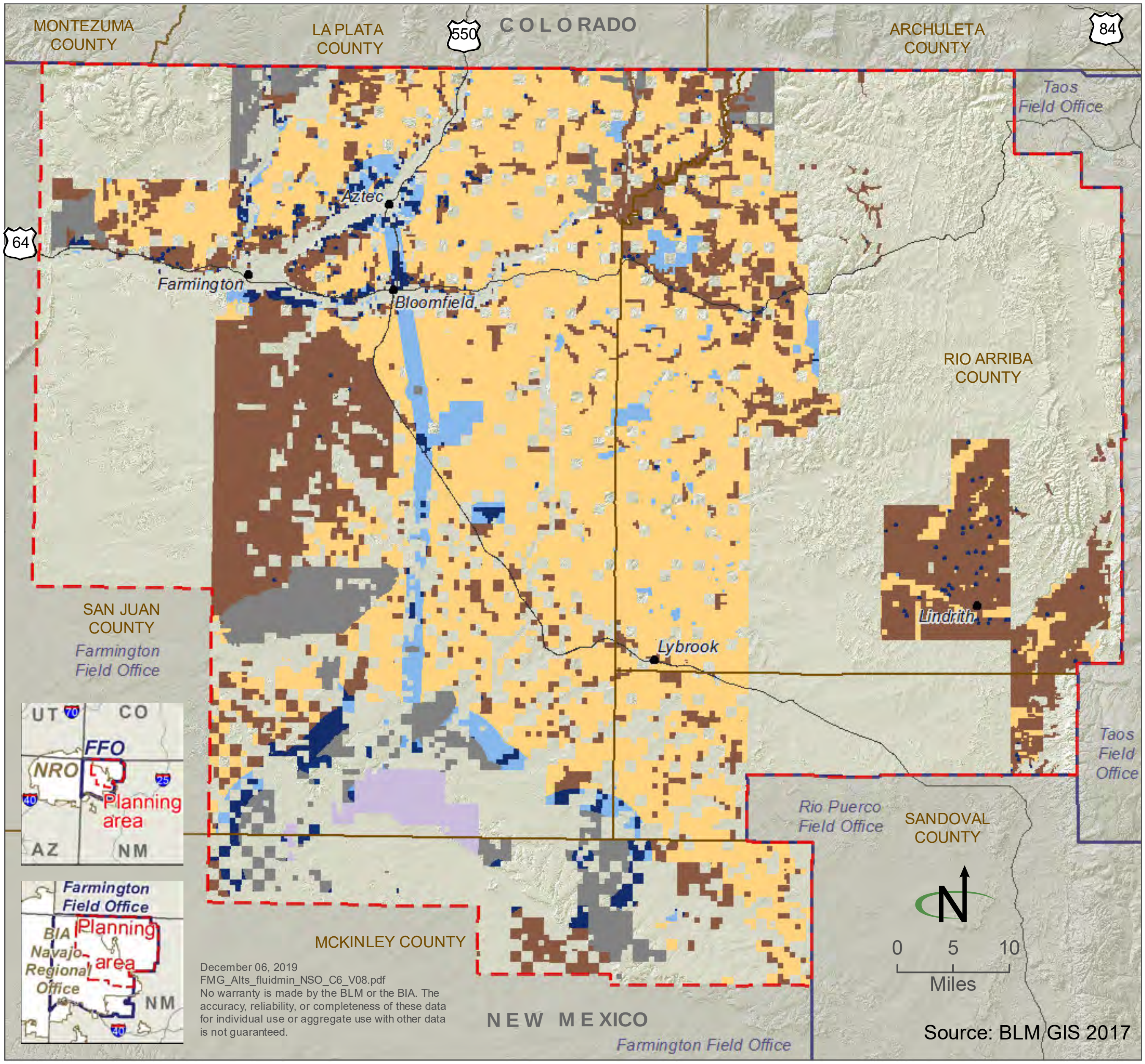
Field office boundary

Figure 2-22
BLM Alternative C5:
No Surface Occupancy for Fluid Mineral Leasing



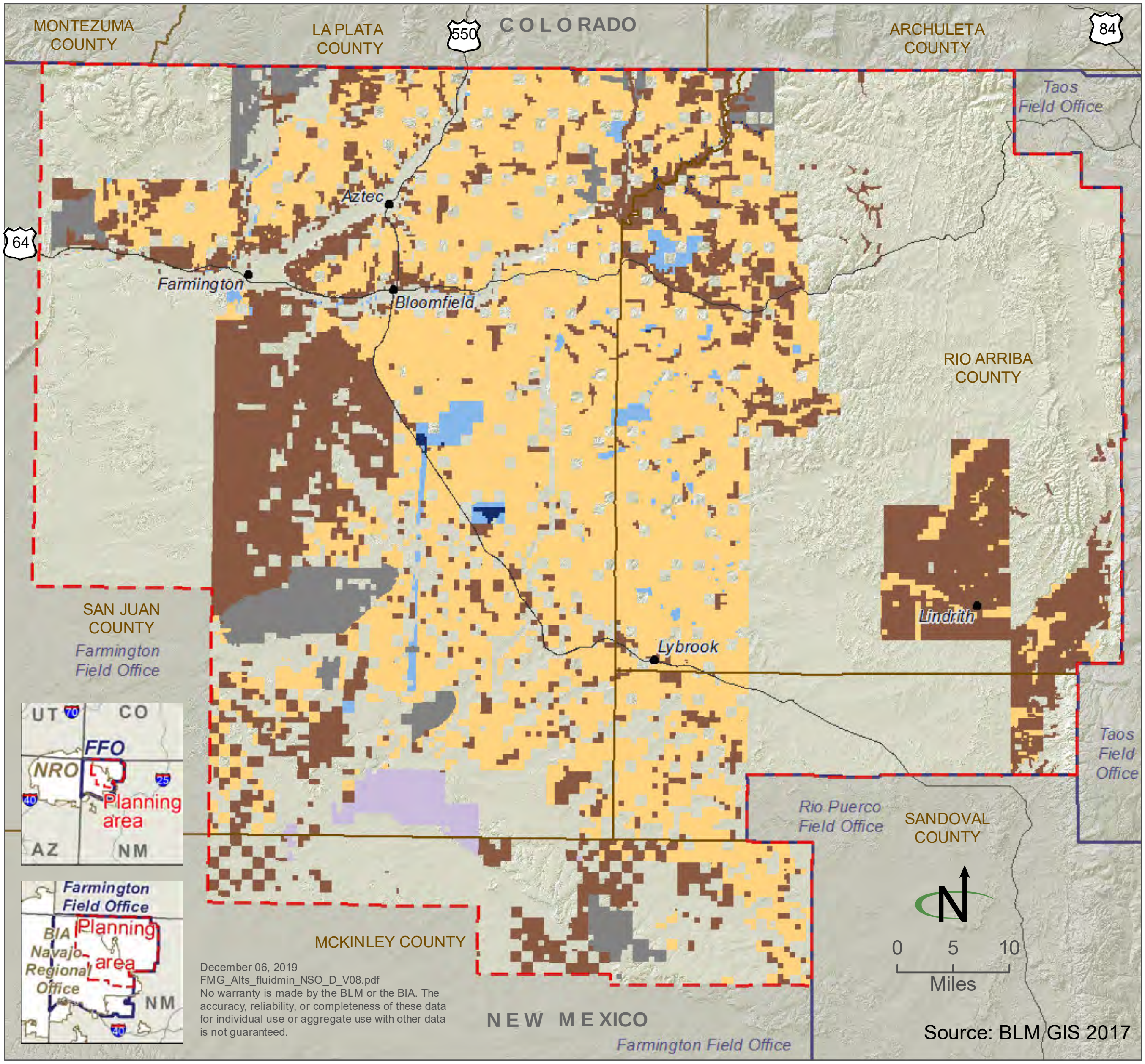
- Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate
- Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-23
BLM Alternative C6:
No Surface Occupancy for Fluid Mineral Leasing



- Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate
- Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-24
BLM Alternative D:
No Surface Occupancy for Fluid Mineral Leasing



Open to leasing, subject to no surface occupancy: BLM surface land and federal mineral estate

Open to leasing, subject to no surface occupancy: Non-BLM surface land and federal mineral estate

Closed to fluid mineral leasing

Open to fluid mineral leasing: BLM surface land and federal mineral estate

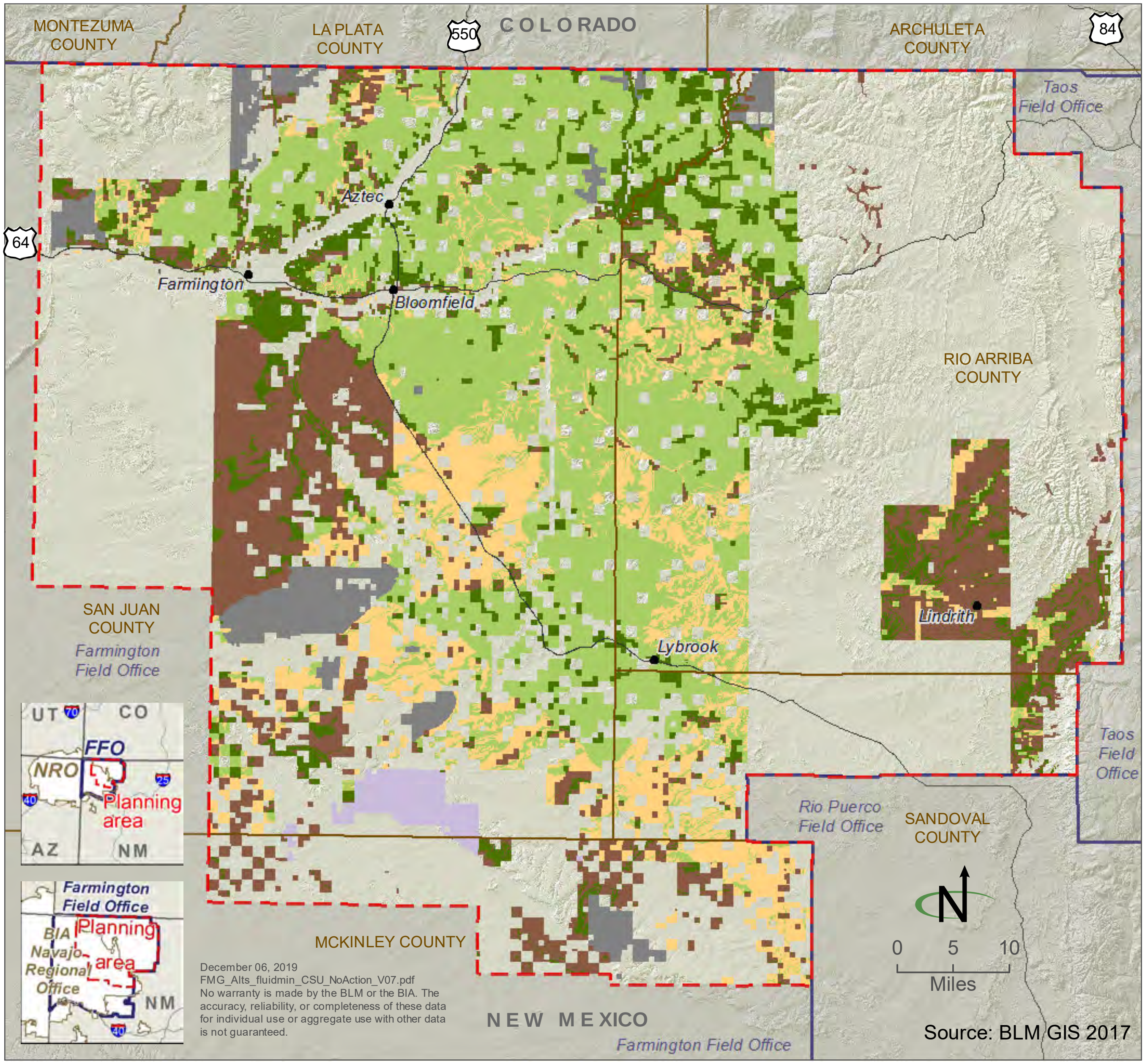
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-25
BLM No Action Alternative: Controlled Surface Use for Fluid Mineral Leasing



Open to leasing, subject to controlled surface use: BLM surface land and federal mineral estate

Open to leasing, subject to controlled surface use: Non-BLM surface land and federal mineral estate

Closed to fluid mineral leasing

Open to fluid mineral leasing: BLM surface land and federal mineral estate

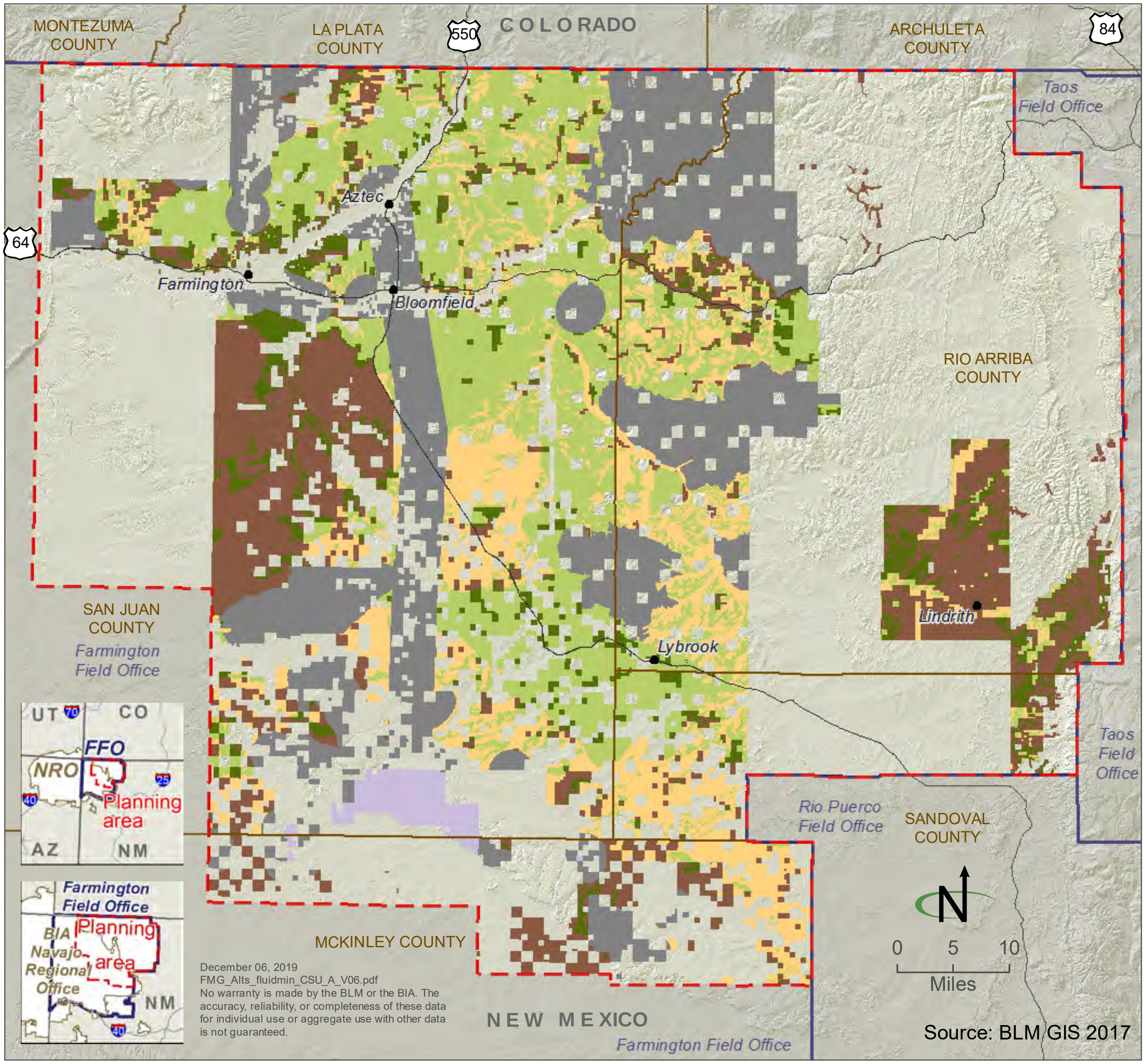
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-26
BLM Alternative A:
Controlled Surface Use for Fluid Mineral Leasing



Open to leasing, subject to controlled surface use: BLM surface land and federal mineral estate

Open to leasing, subject to controlled surface use: Non-BLM surface land and federal mineral estate

Closed to fluid mineral leasing

Open to fluid mineral leasing: BLM surface land and federal mineral estate

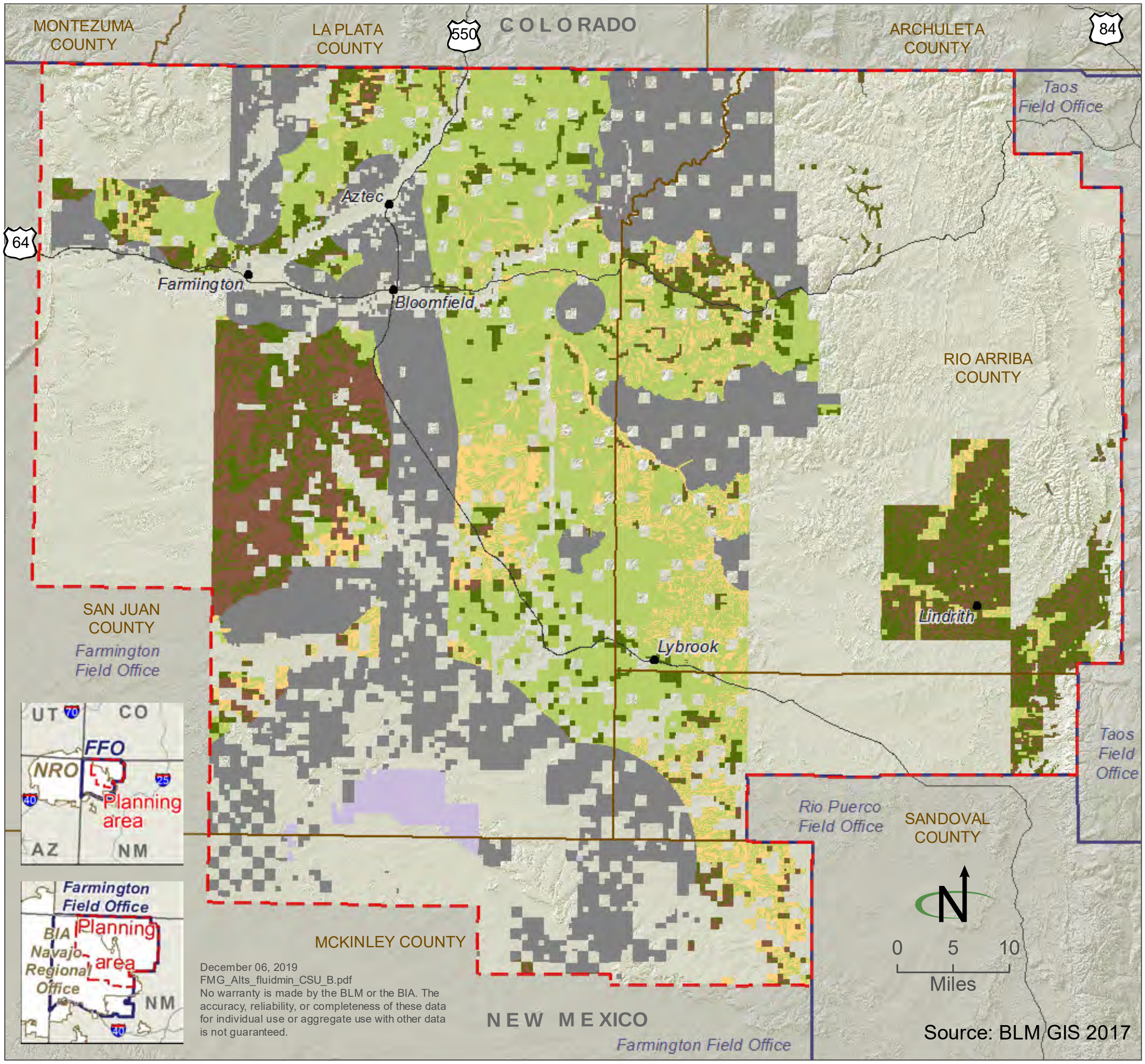
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

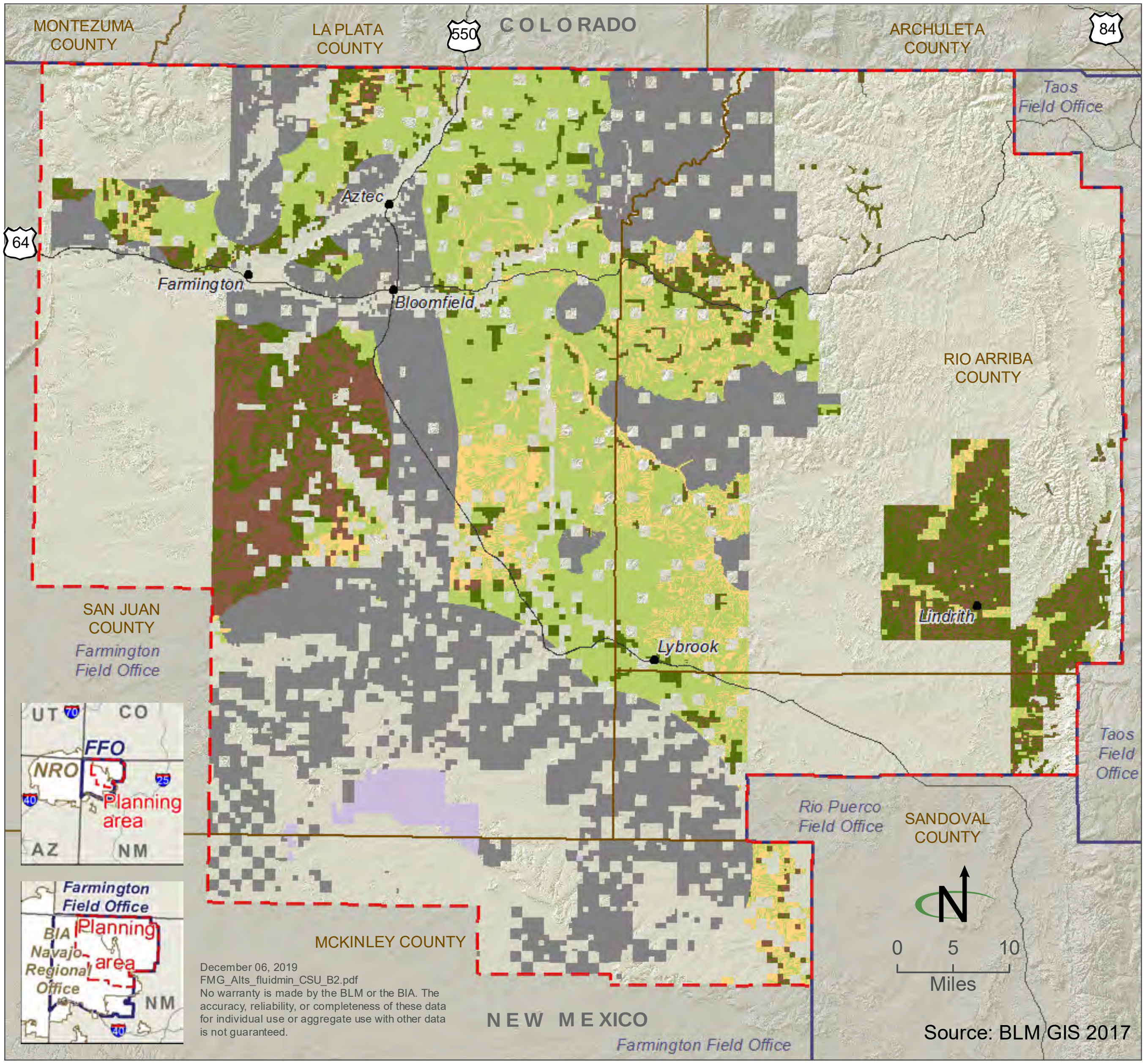
Field office boundary

Figure 2-27
BLM Sub-Alternative B1:
Controlled Surface Use for Fluid Mineral Leasing



- Open to leasing, subject to controlled surface use: BLM surface land and federal mineral estate
- Open to leasing, subject to controlled surface use: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-28
BLM Sub-Alternative B2:
Controlled Surface Use for Fluid Mineral Leasing



Open to leasing, subject to controlled surface use: BLM surface land and federal mineral estate

Open to leasing, subject to controlled surface use: Non-BLM surface land and federal mineral estate

Closed to fluid mineral leasing

Open to fluid mineral leasing: BLM surface land and federal mineral estate

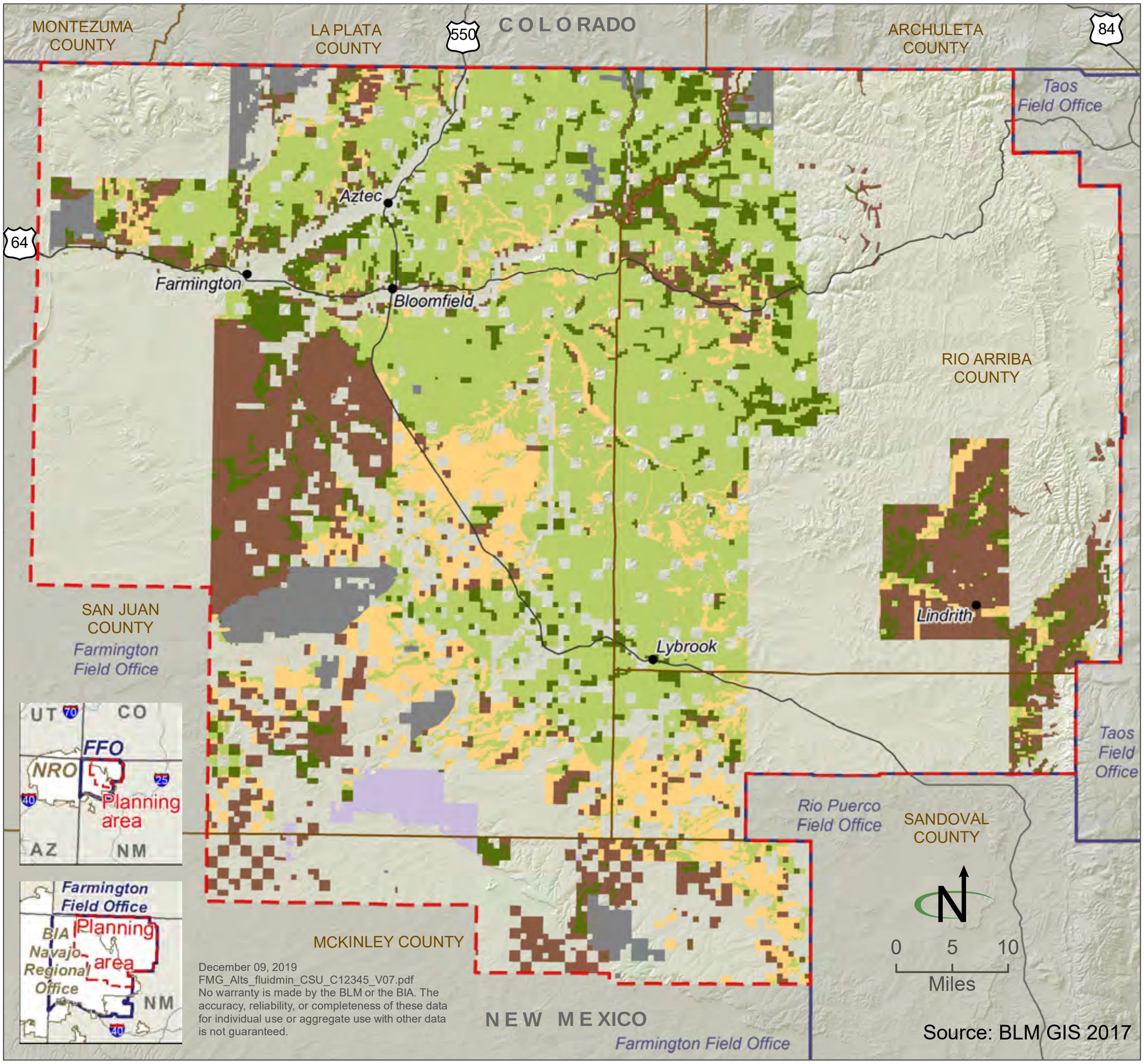
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

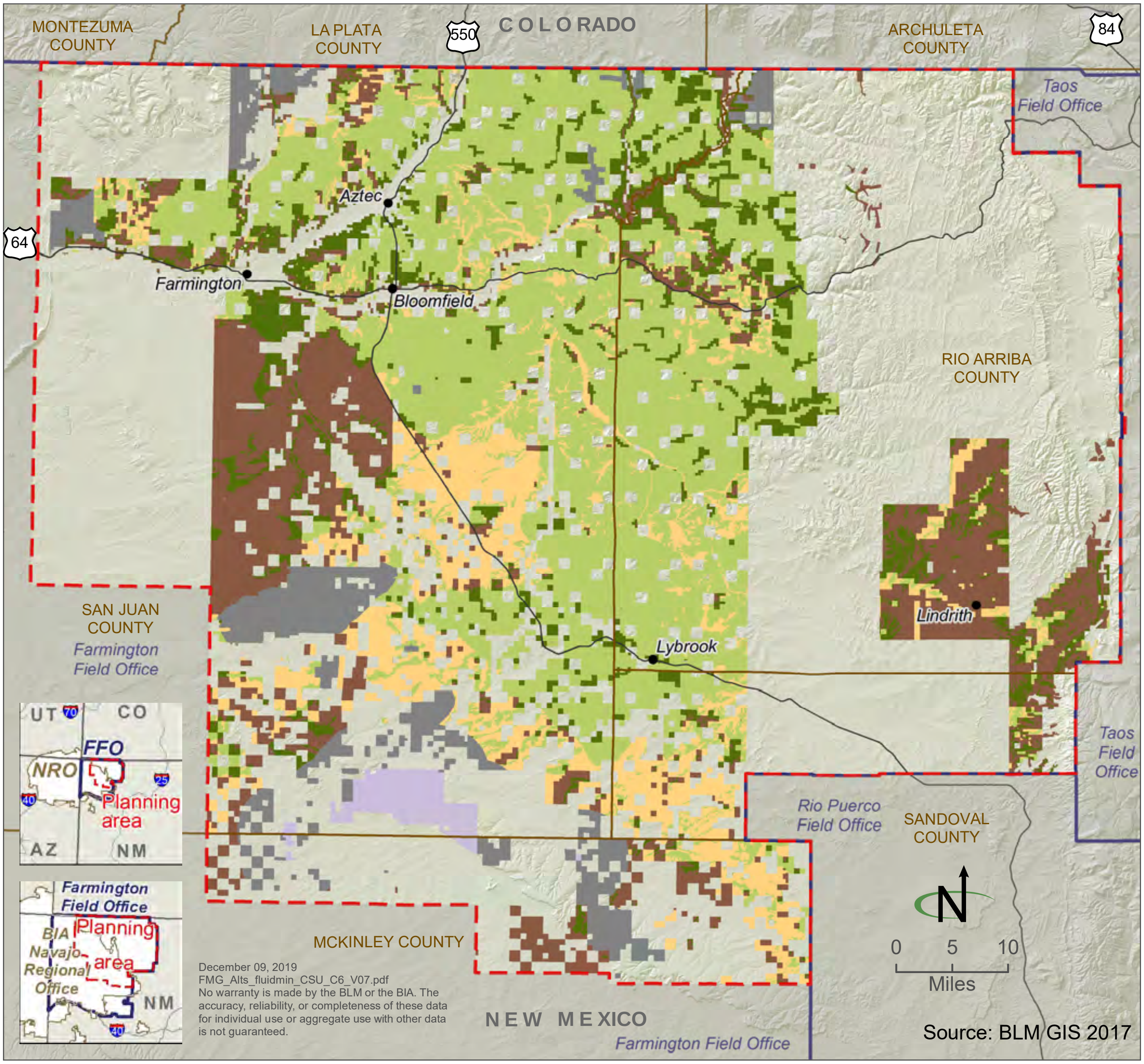
Field office boundary

Figure 2-29
BLM Sub-Alternatives C1-C5:
Controlled Surface Use for Fluid Mineral Leasing



- Open to leasing, subject to controlled surface use: BLM surface land and federal mineral estate
- Open to leasing, subject to controlled surface use: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-30
BLM Sub-Alternative C6:
Controlled Surface Use for Fluid Mineral Leasing



- Open to leasing, subject to controlled surface use: BLM surface land and federal mineral estate
- Open to leasing, subject to controlled surface use: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-31
BLM Alternative D:
Controlled Surface Use for Fluid Mineral Leasing

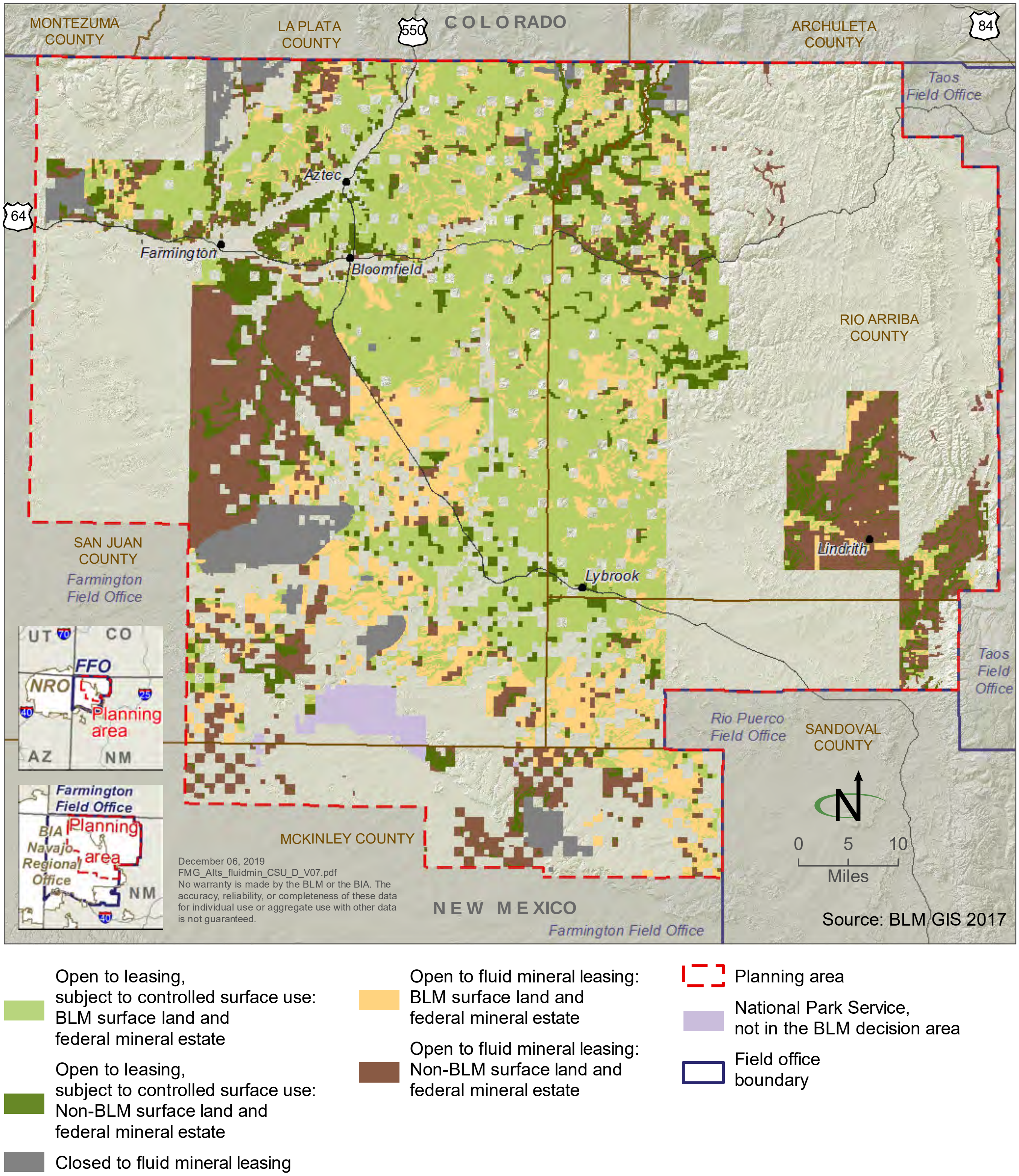
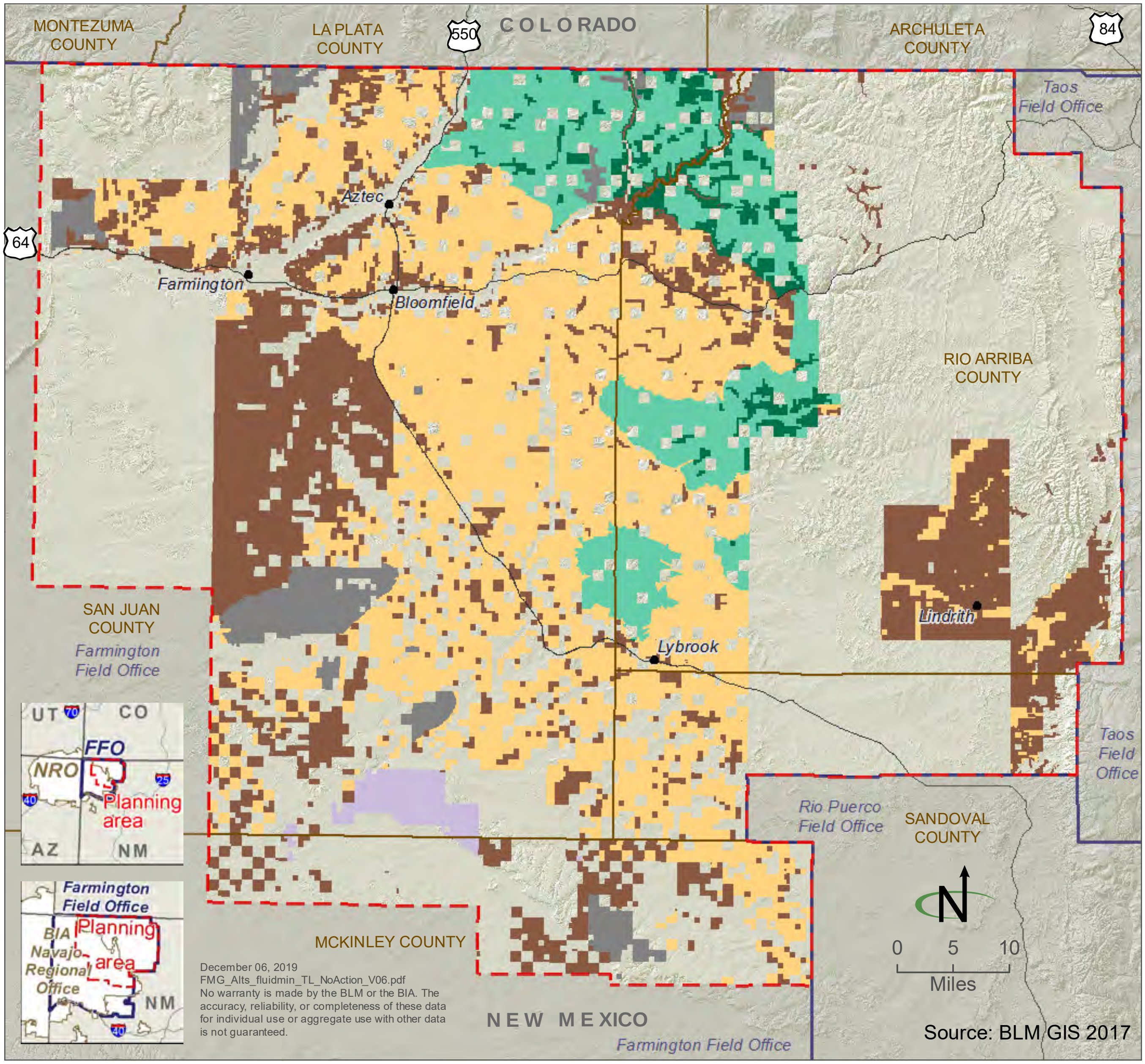


Figure 2-32
BLM No Action Alternative:
Timing Limitations for Fluid Mineral Leasing



Open to leasing, subject to timing limitations: BLM surface land and federal mineral estate

Open to leasing, subject to timing limitations: Non-BLM surface land and federal mineral estate

Closed to fluid mineral leasing

Open to fluid mineral leasing: BLM surface land and federal mineral estate

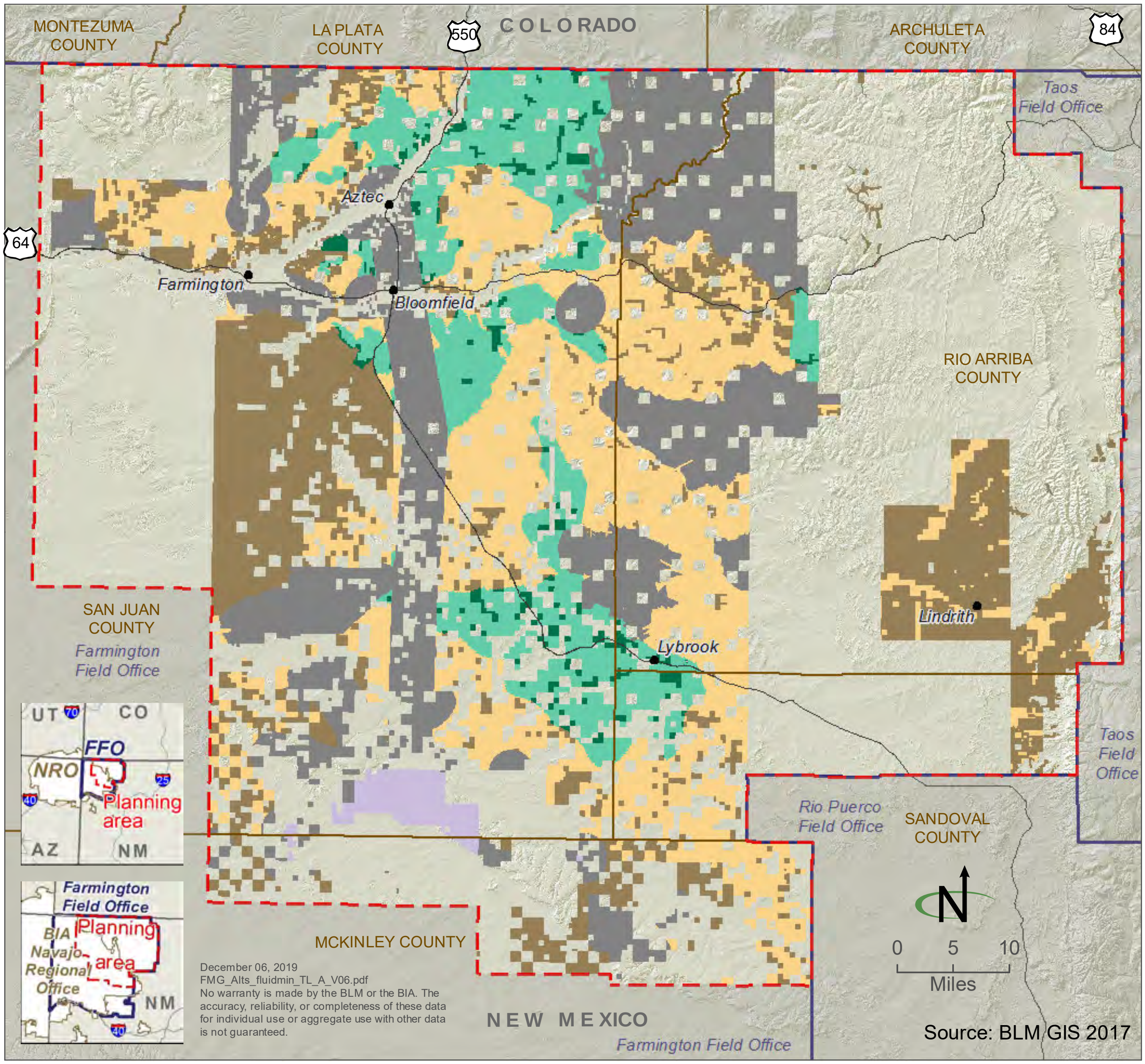
Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate

Planning area

National Park Service, not in the BLM decision area

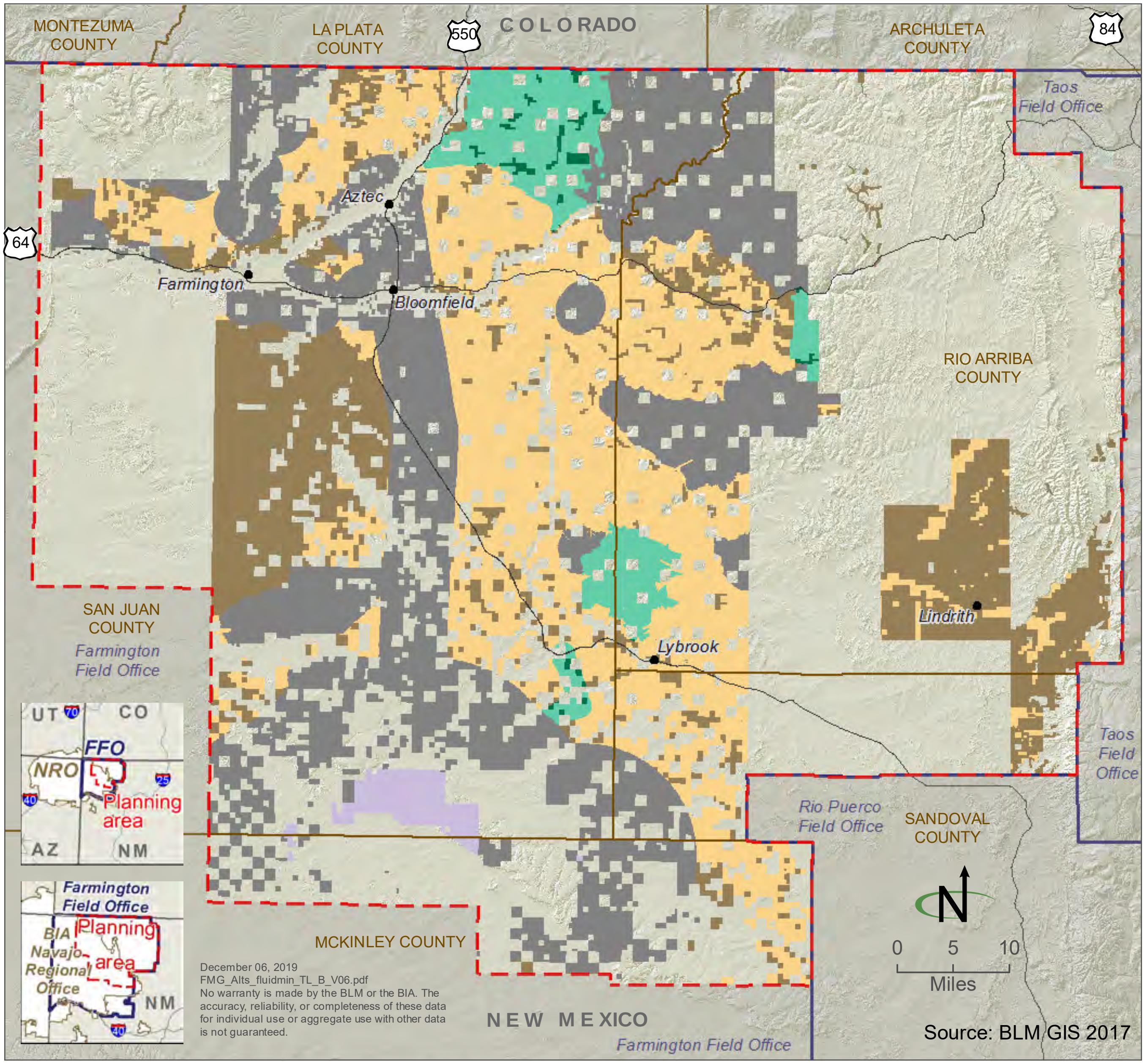
Field office boundary

Figure 2-33
BLM Alternative A:
Timing Limitations for Fluid Mineral Leasing



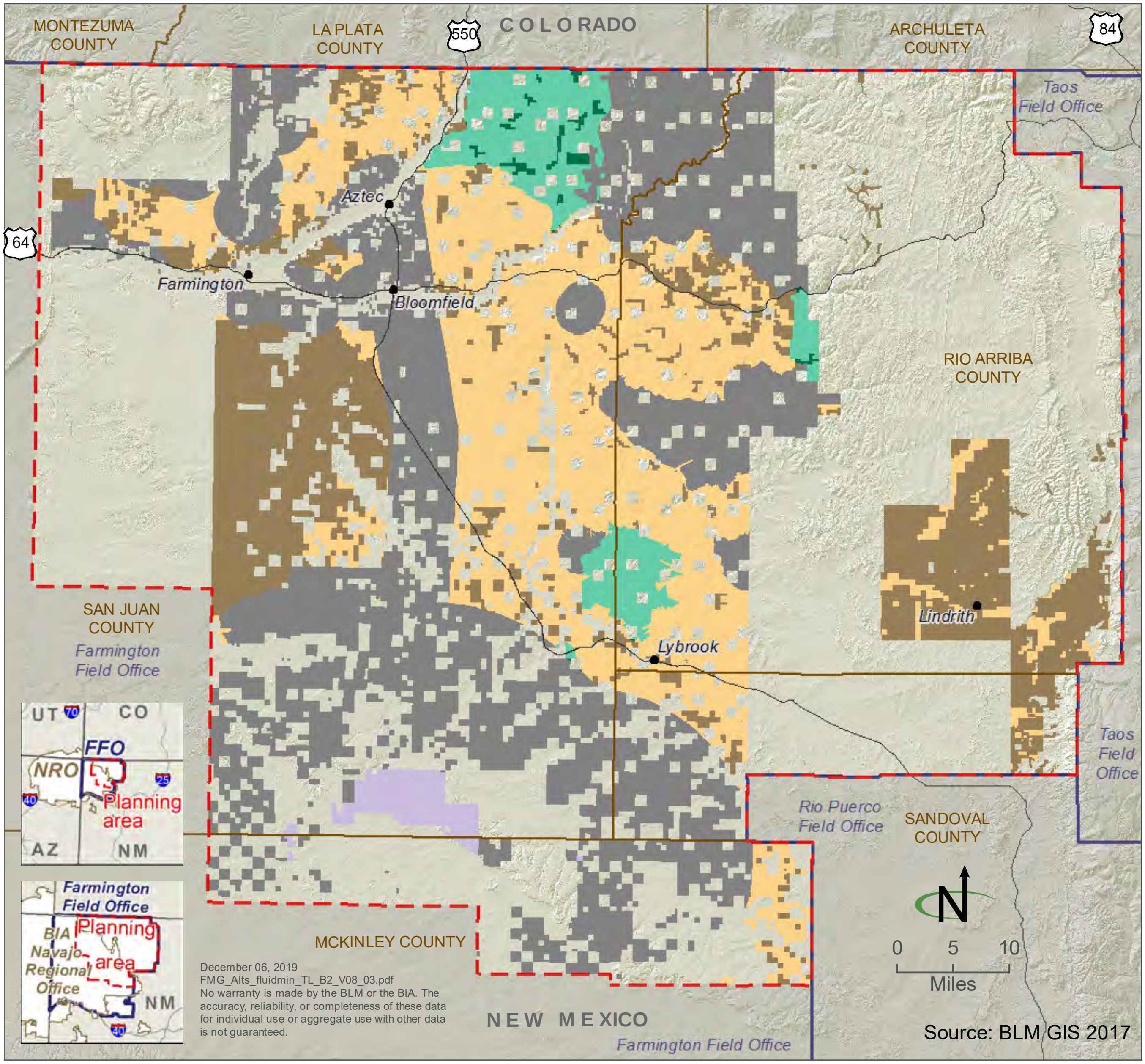
- Open to leasing, subject to timing limitations: BLM surface land and federal mineral estate
- Open to leasing, subject to timing limitations: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-34
BLM Sub-Alternative B1:
Timing Limitations for Fluid Mineral Leasing



- Open to leasing, subject to timing limitations: BLM surface land and federal mineral estate
- Open to leasing, subject to timing limitations: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-35
BLM Sub-Alternative B2:
Timing Limitations for Fluid Mineral Leasing



- Open to leasing, subject to timing limitations: BLM surface land and federal mineral estate
- Open to leasing, subject to timing limitations: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-36
BLM Sub-Alternatives C1-C6: Timing Limitations for Fluid Mineral Leasing

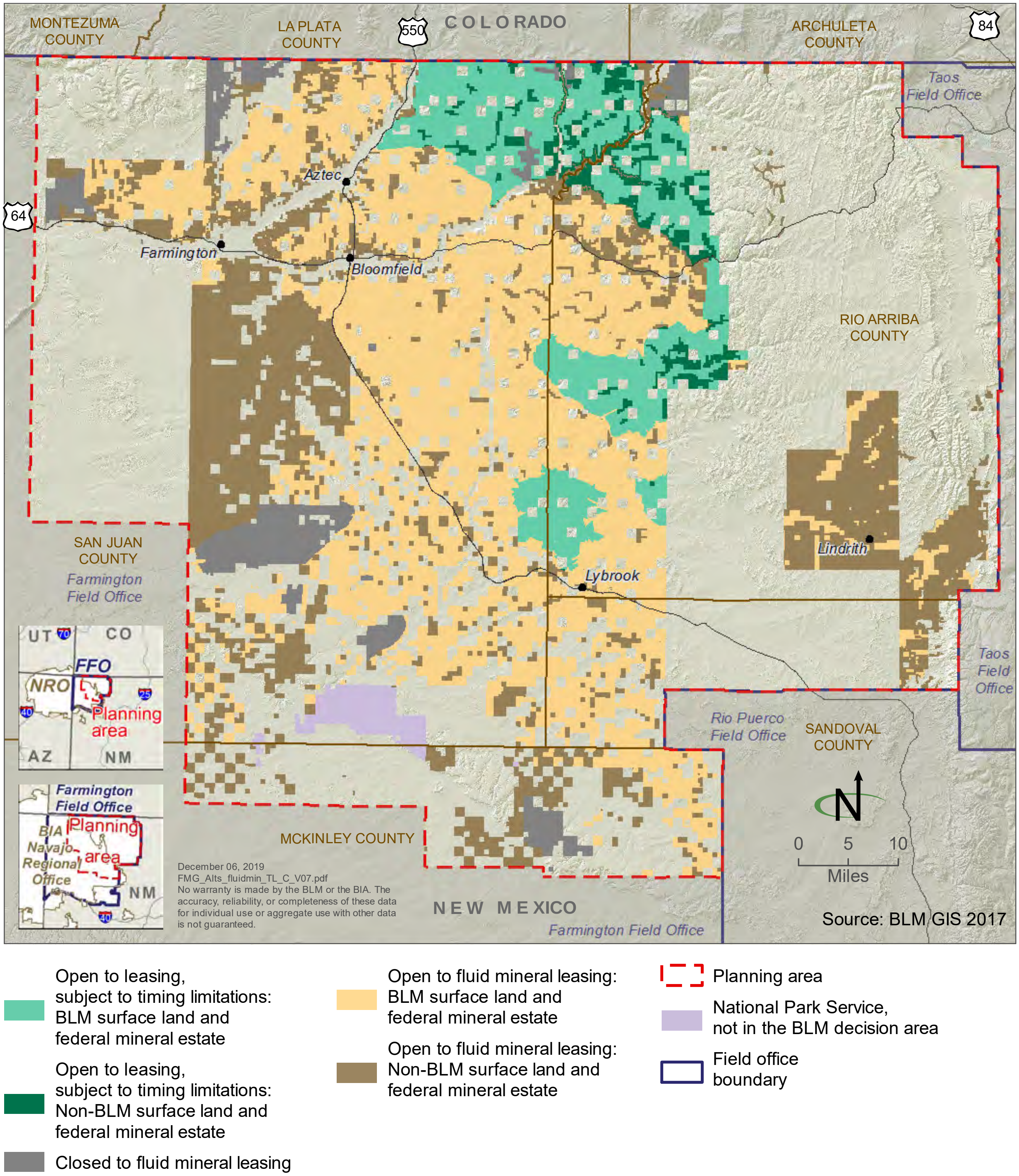
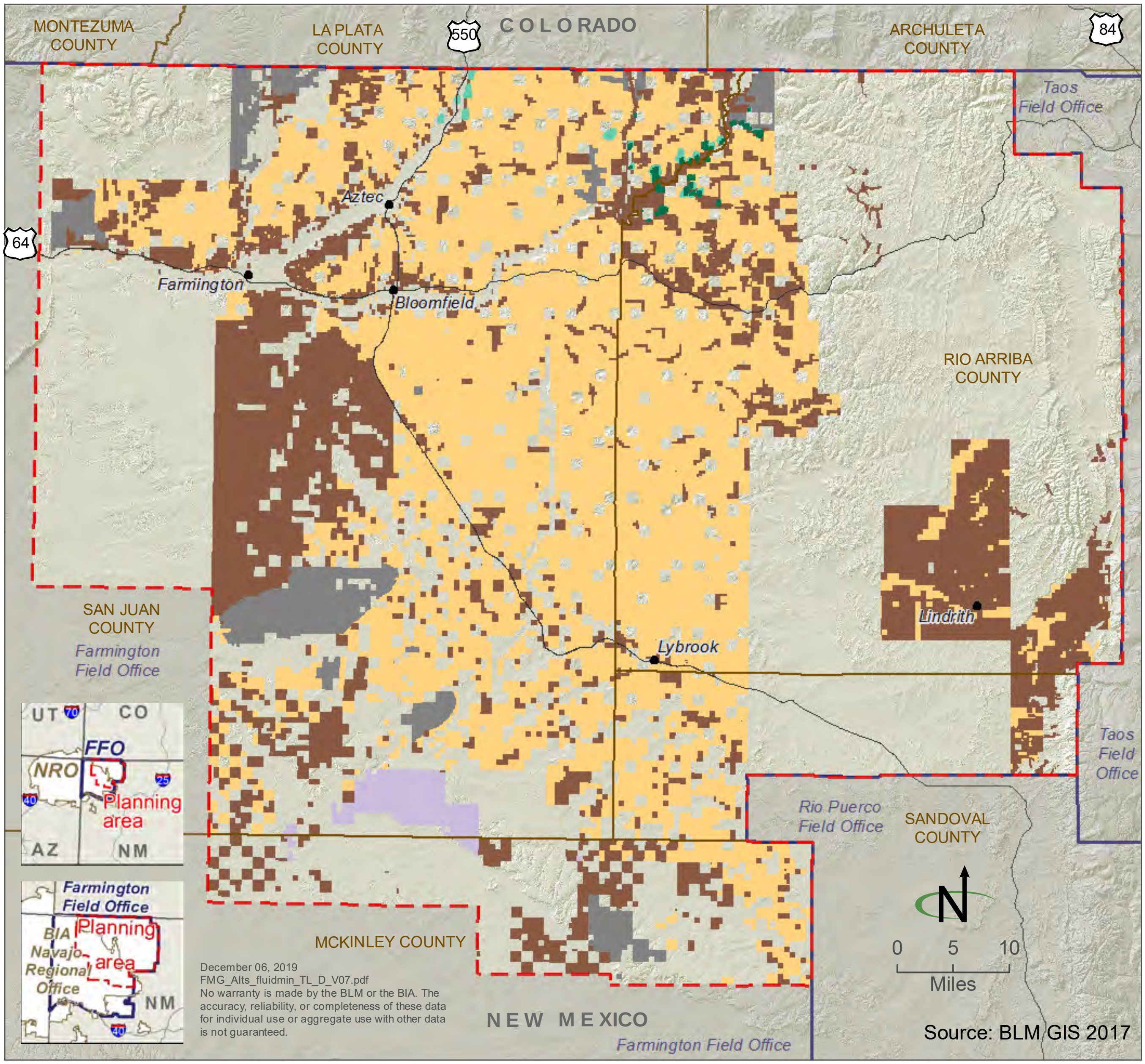


Figure 2-37
BLM Alternative D:
Timing Limitations for Fluid Mineral Leasing



- Open to leasing, subject to timing limitations: BLM surface land and federal mineral estate
- Open to leasing, subject to timing limitations: Non-BLM surface land and federal mineral estate
- Closed to fluid mineral leasing
- Open to fluid mineral leasing: BLM surface land and federal mineral estate
- Open to fluid mineral leasing: Non-BLM surface land and federal mineral estate
- Planning area
- National Park Service, not in the BLM decision area
- Field office boundary

Figure 2-38
BLM Alternative A:
Right-of-Way Exclusion and Avoidance

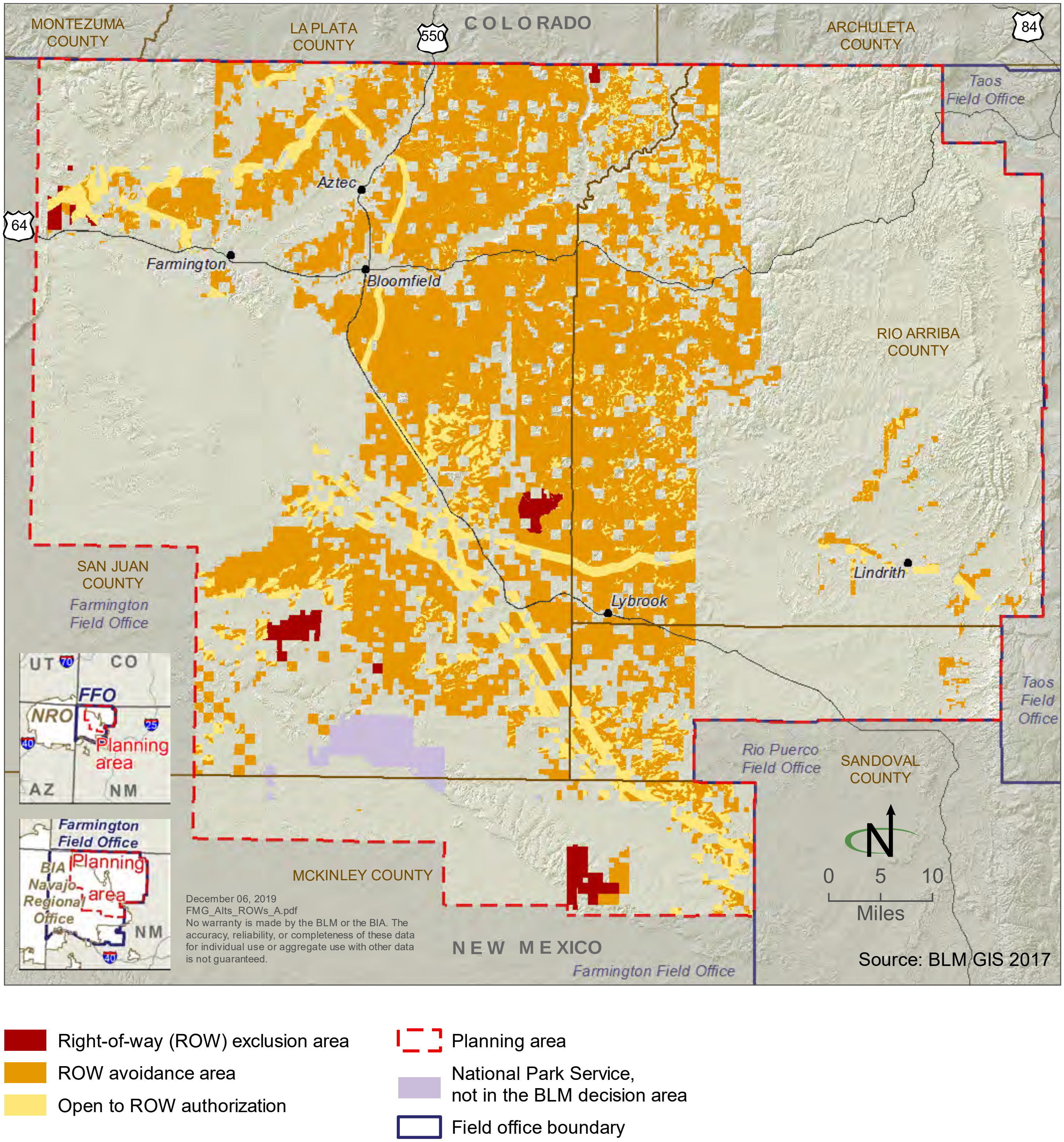
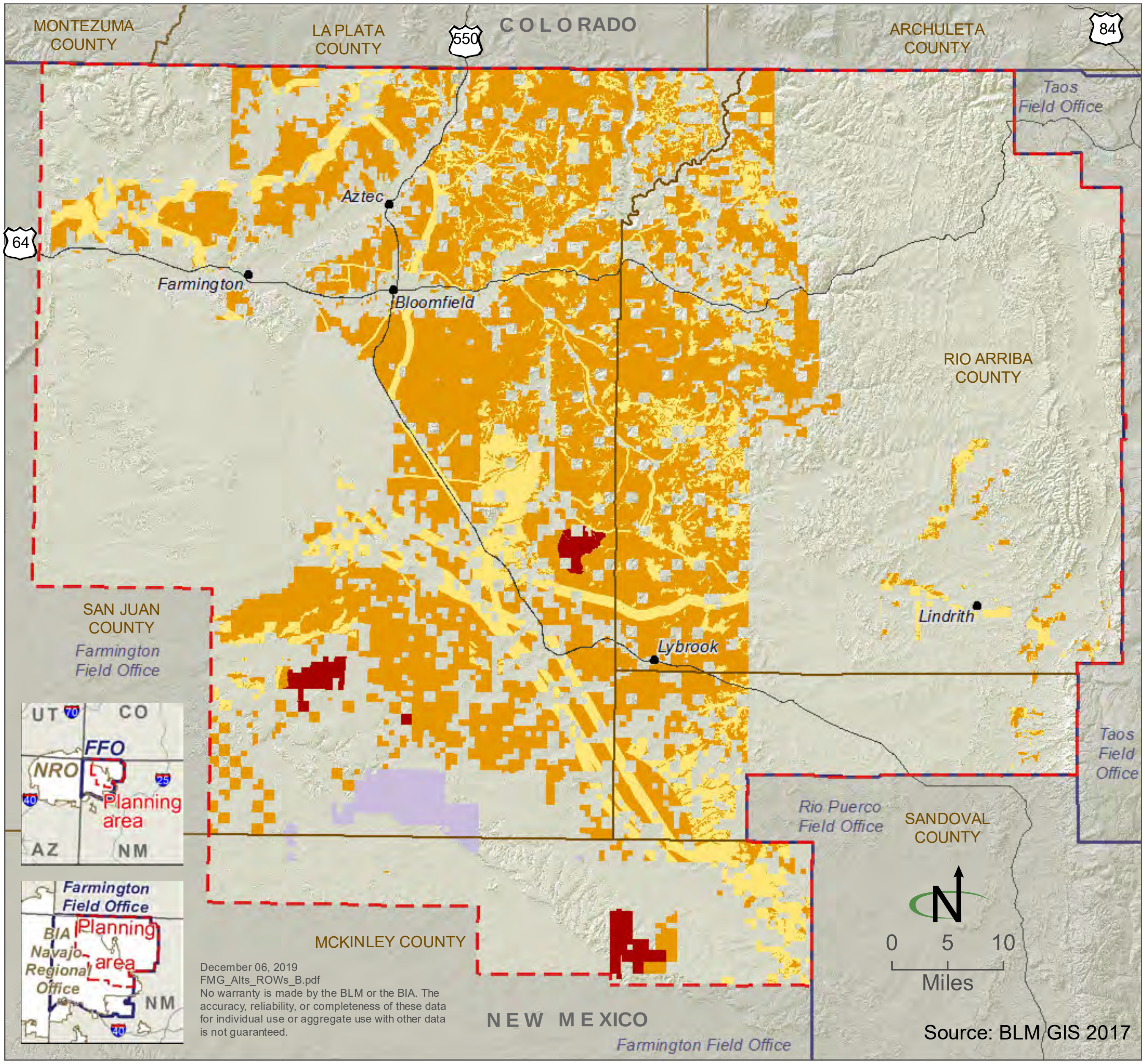


Figure 2-39
BLM Alternative B:
Right-of-Way Exclusion and Avoidance



Right-of-way (ROW) exclusion area

Right-of-way (ROW) avoidance area

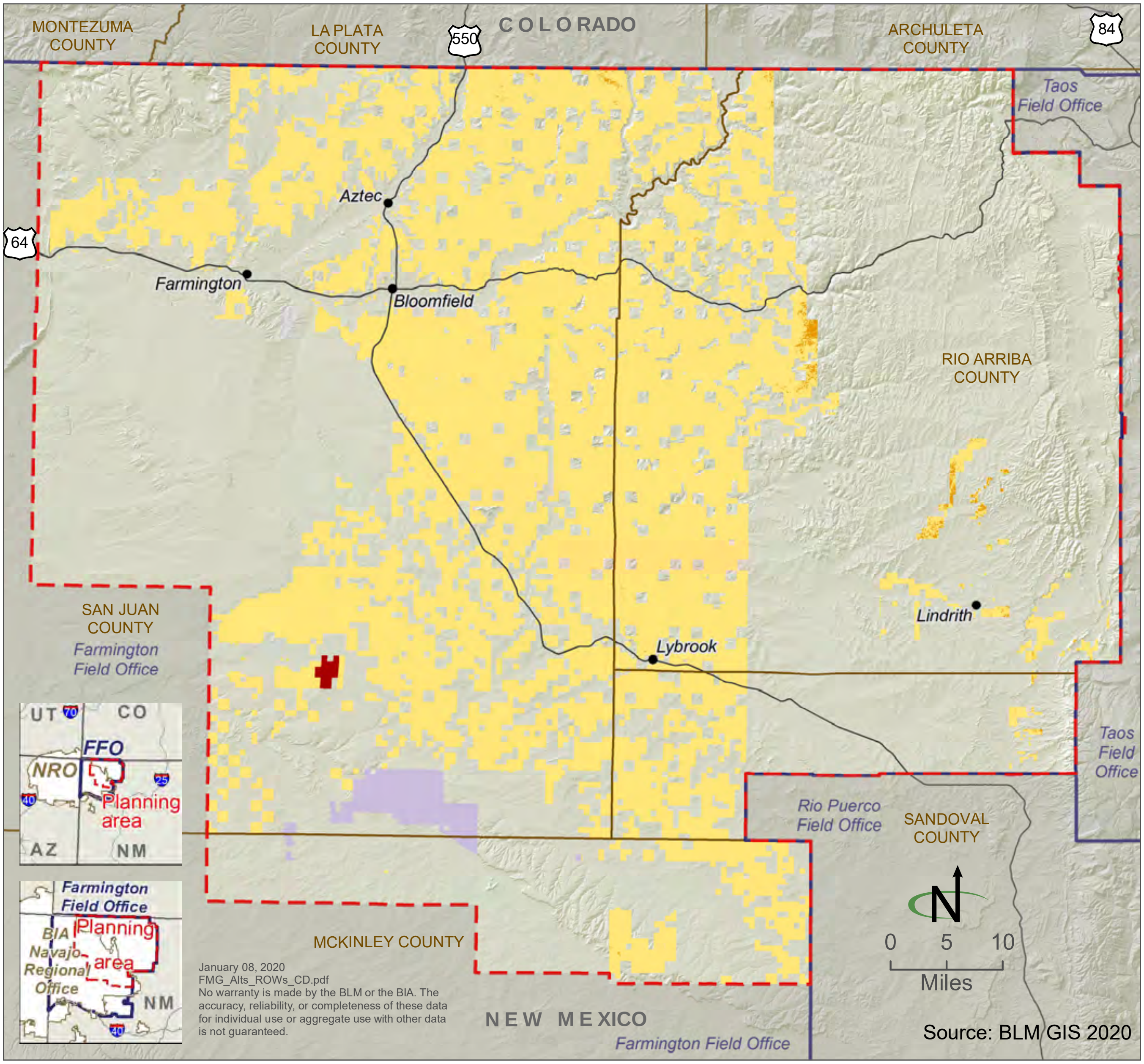
Open to right-of-way (ROW) authorization

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-40
BLM Alternatives C and D:
Right-of-Way Exclusion and Avoidance



Right-of-way (ROW) exclusion area
Right-of-way (ROW) avoidance area
Open to right-of-way (ROW) authorization
Planning area
National Park Service, not in the BLM decision area
Field office boundary

Figure 2-41
BLM No Action Alternative: Utility Corridors

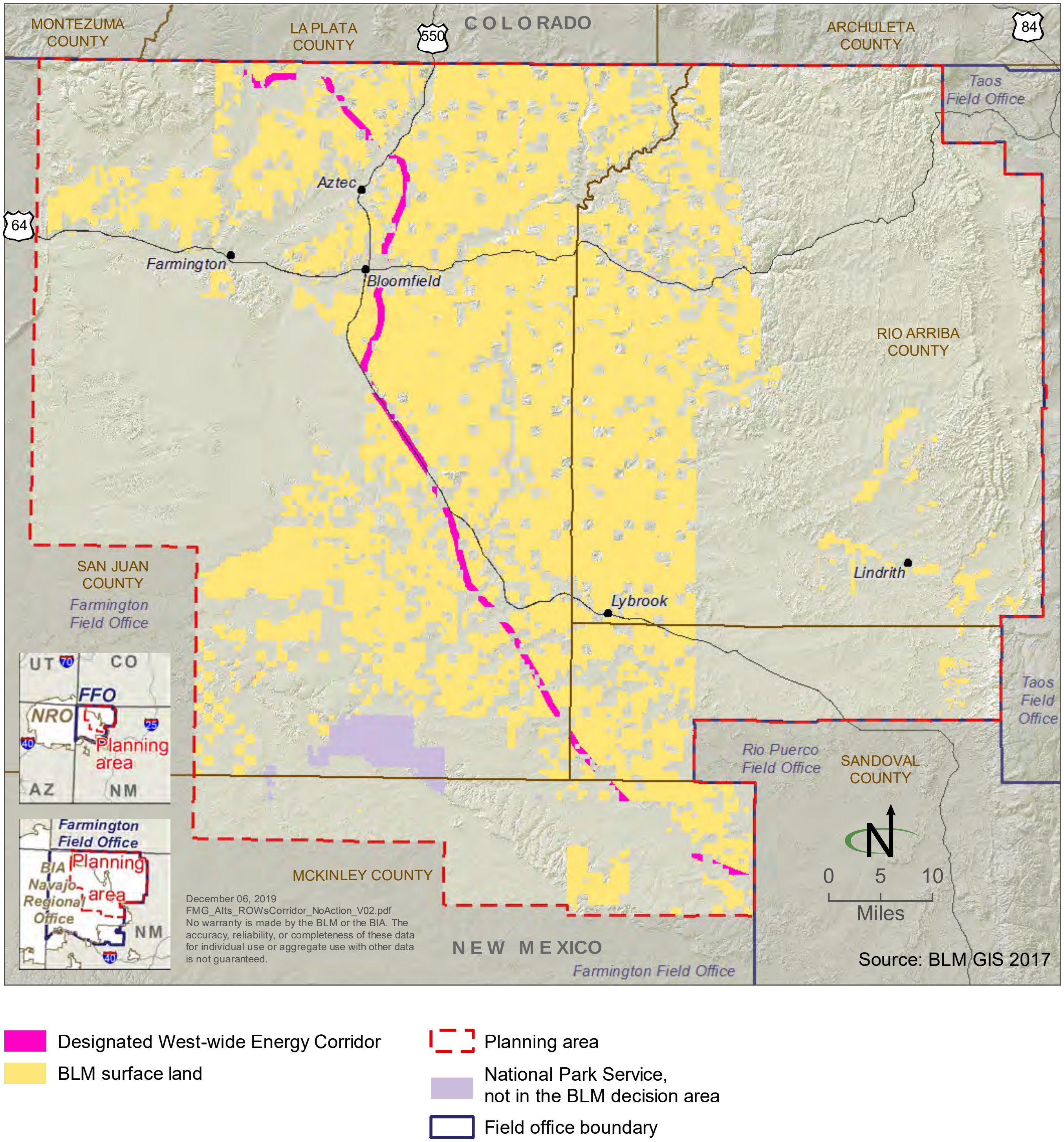


Figure 2-42
BLM Alternative A: Utility Corridors

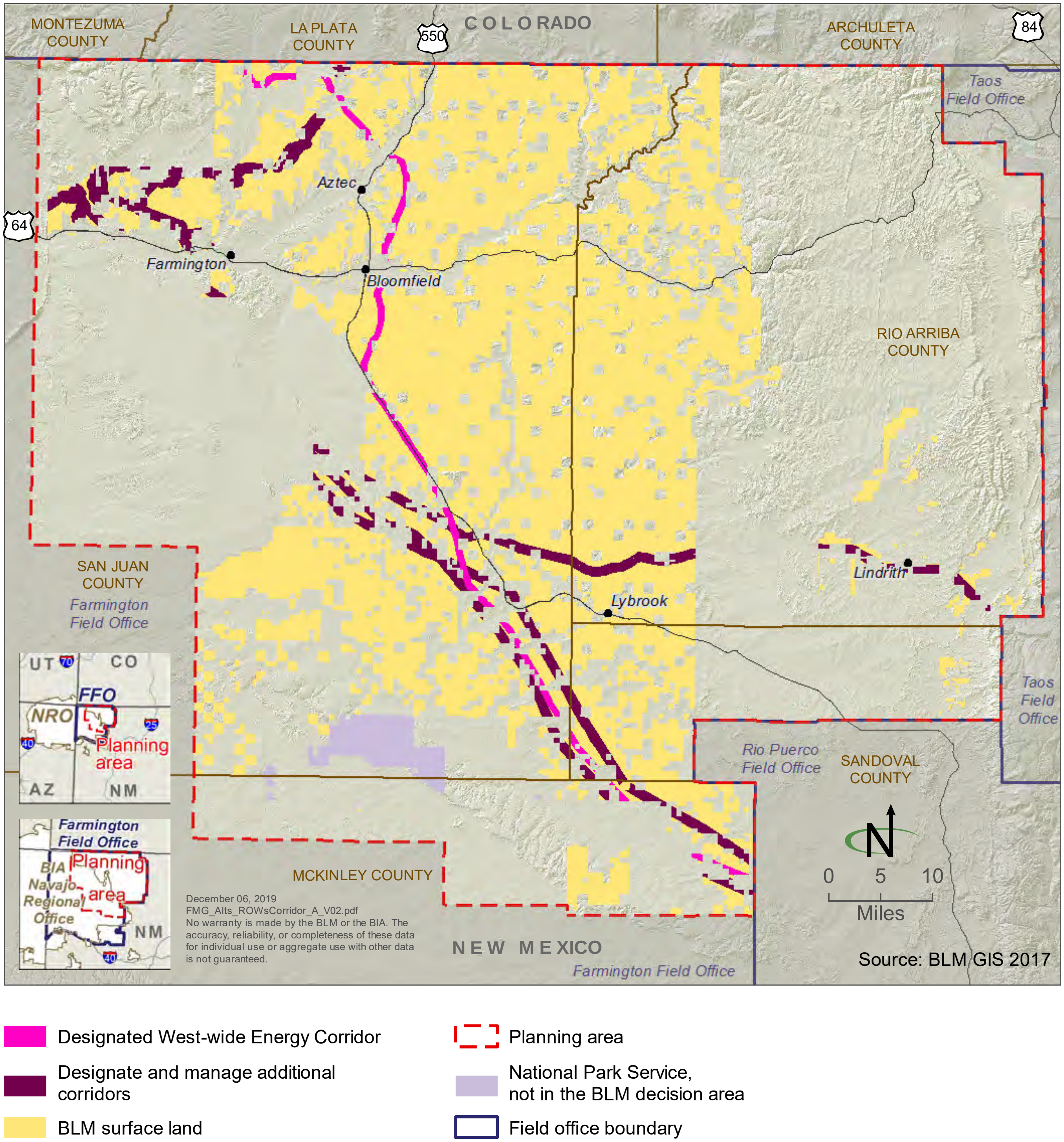
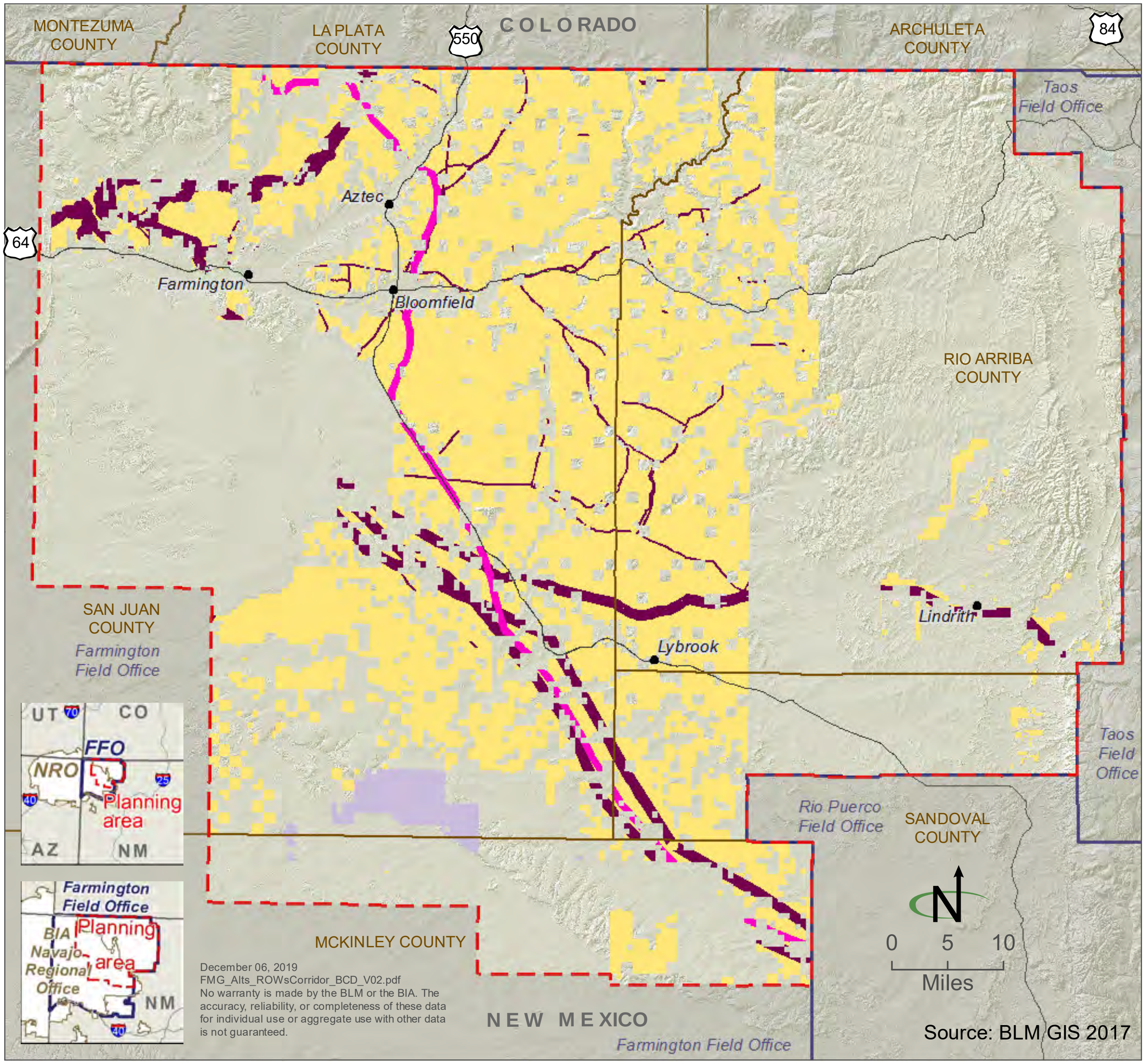


Figure 2-43
BLM Alternatives B, C, and D: Utility Corridors



Designated West-wide Energy Corridor

Designate and manage additional corridors

BLM surface land

Planning area

National Park Service, not in the BLM decision area

Field office boundary

Figure 2-44
BLM Alternatives A, B, C, and D: Identified for Exchange

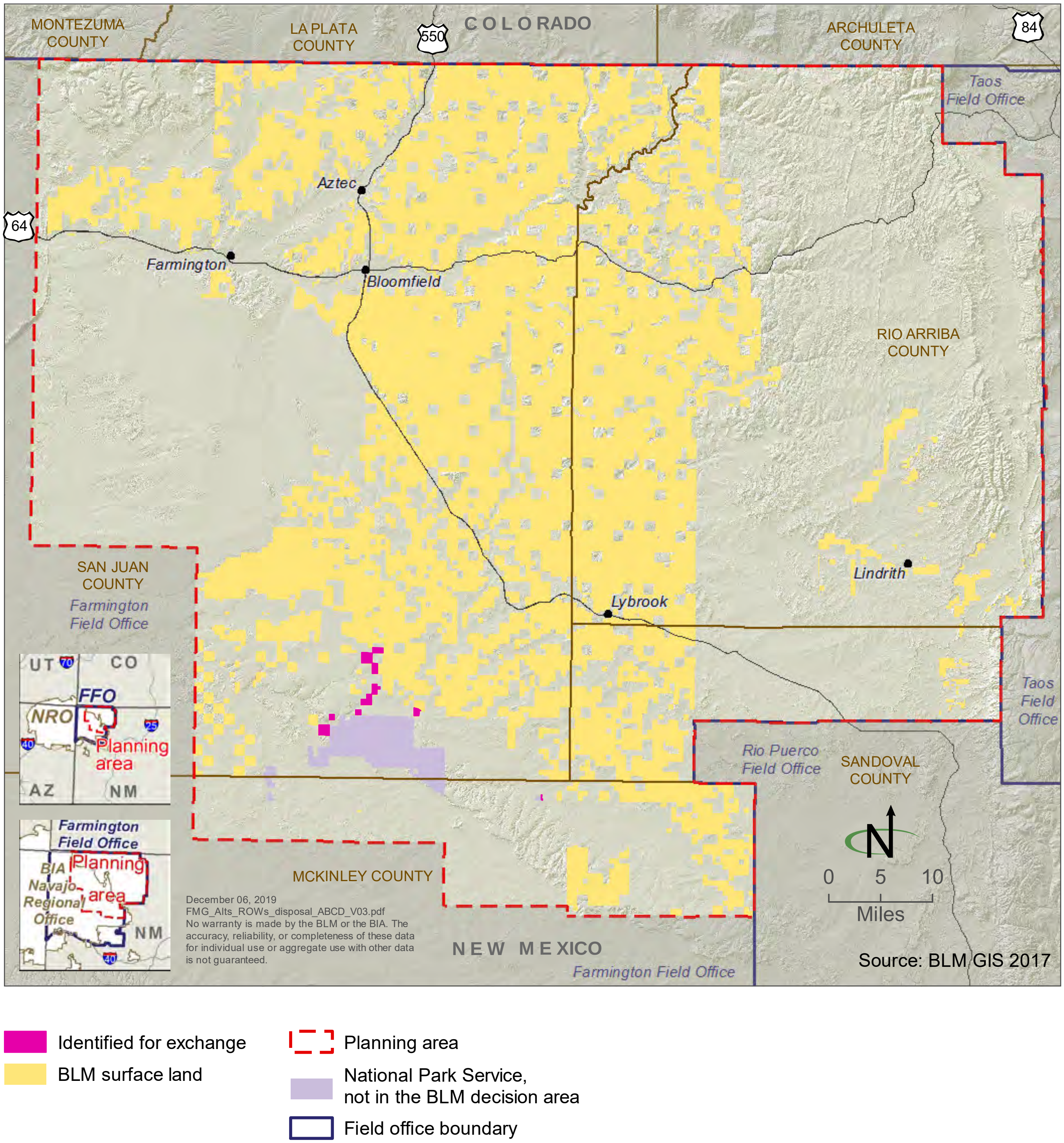
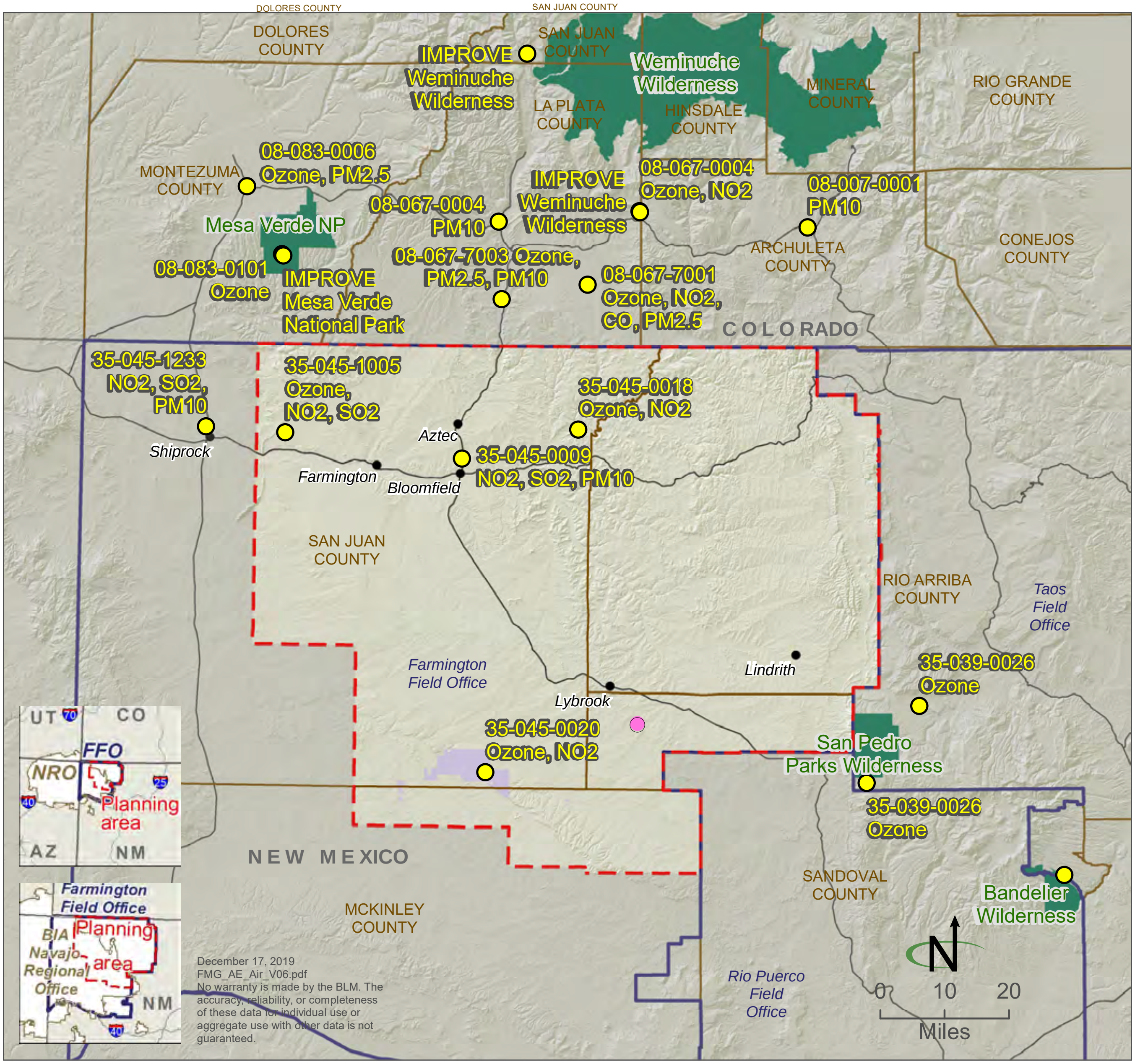


Figure 3-1
Air Quality Monitoring Stations

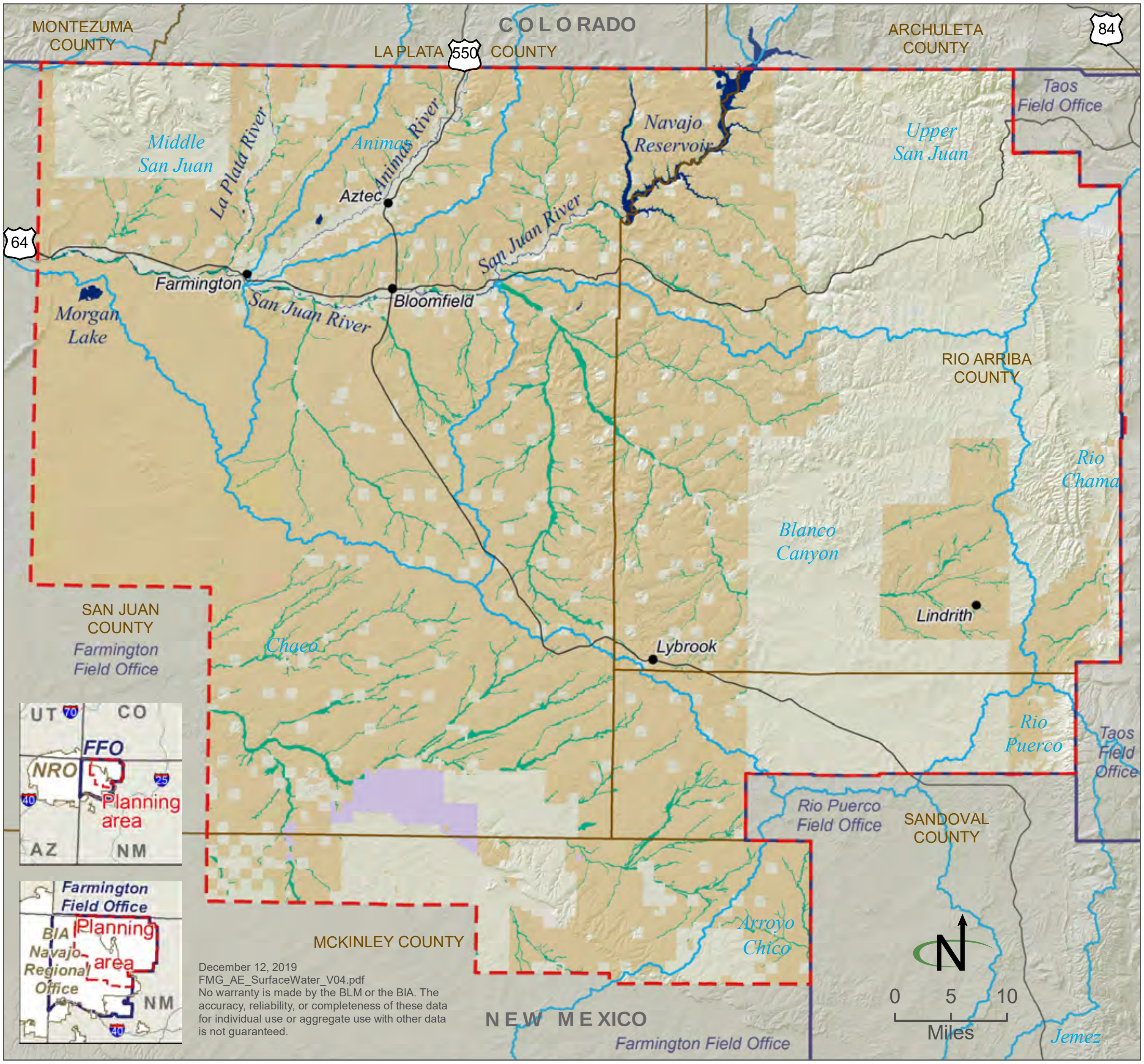


Source: BLM GIS 2020

- Air monitoring station
- Temporary NNEPA monitoring station (2016)
- Class 1 airshed
- Planning area
- National Park Service
- Field office boundary

Figure 3-7
Surface Water

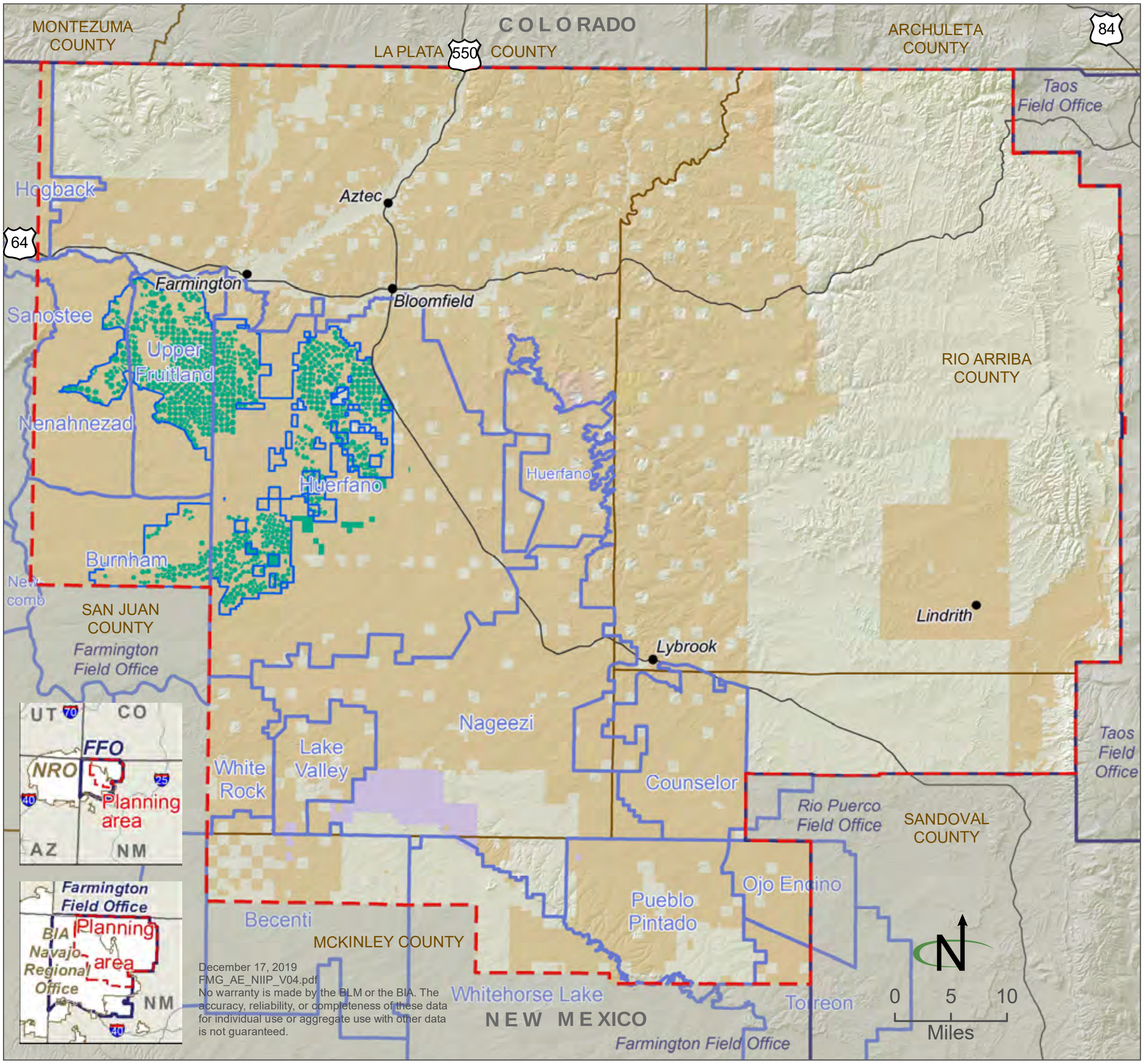
Watersheds in the United States were delineated by the US Geological Survey using a national standard hierarchical system based on surface hydrologic features. The boundary between watersheds is defined as the topographic dividing line from which water flows in two different directions. The planning area contains 8 cataloguing units (organized as fourth-level hydrologic unit codes [HUC 8]).



Source: BLM GIS 2020

- Major lake and reservoir
- Major river and stream
- Watershed (HUC 8)
- 100-year floodplain
- BLM and BIA decision area
- Planning area
- National Park Service
- Field office boundary

Figure 3-8
Navajo Indian Irrigation Project

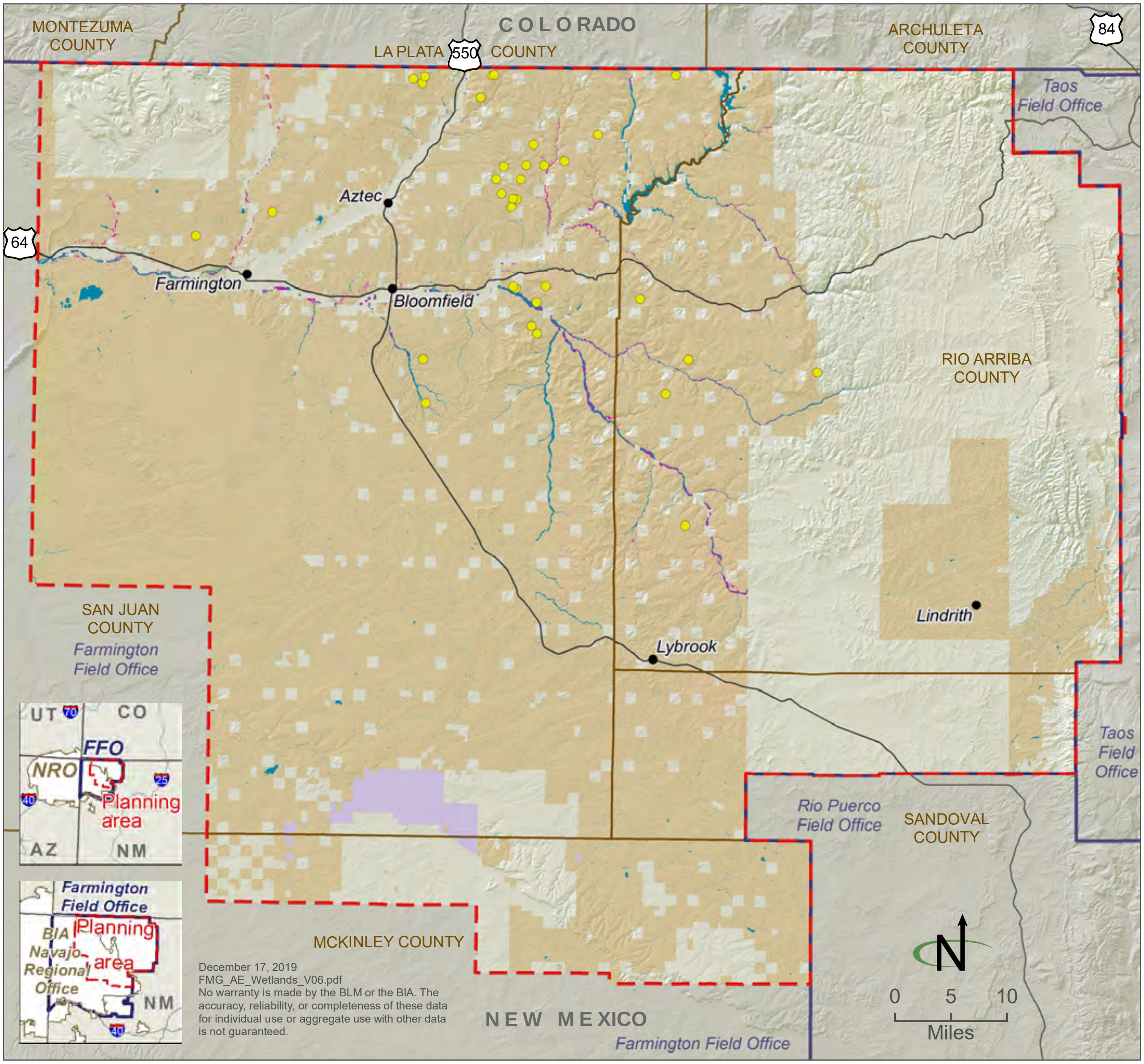


Source: BLM GIS 2020

- Navajo Indian Irrigation Project
- Navajo Indian Irrigation Project block
- BLM and BIA decision area
- Planning area
- National Park Service
- Field office boundary
- Navajo Nation Chapter

Figure 3-9
Current Inventory Wetlands, Riparian Areas, and Springs

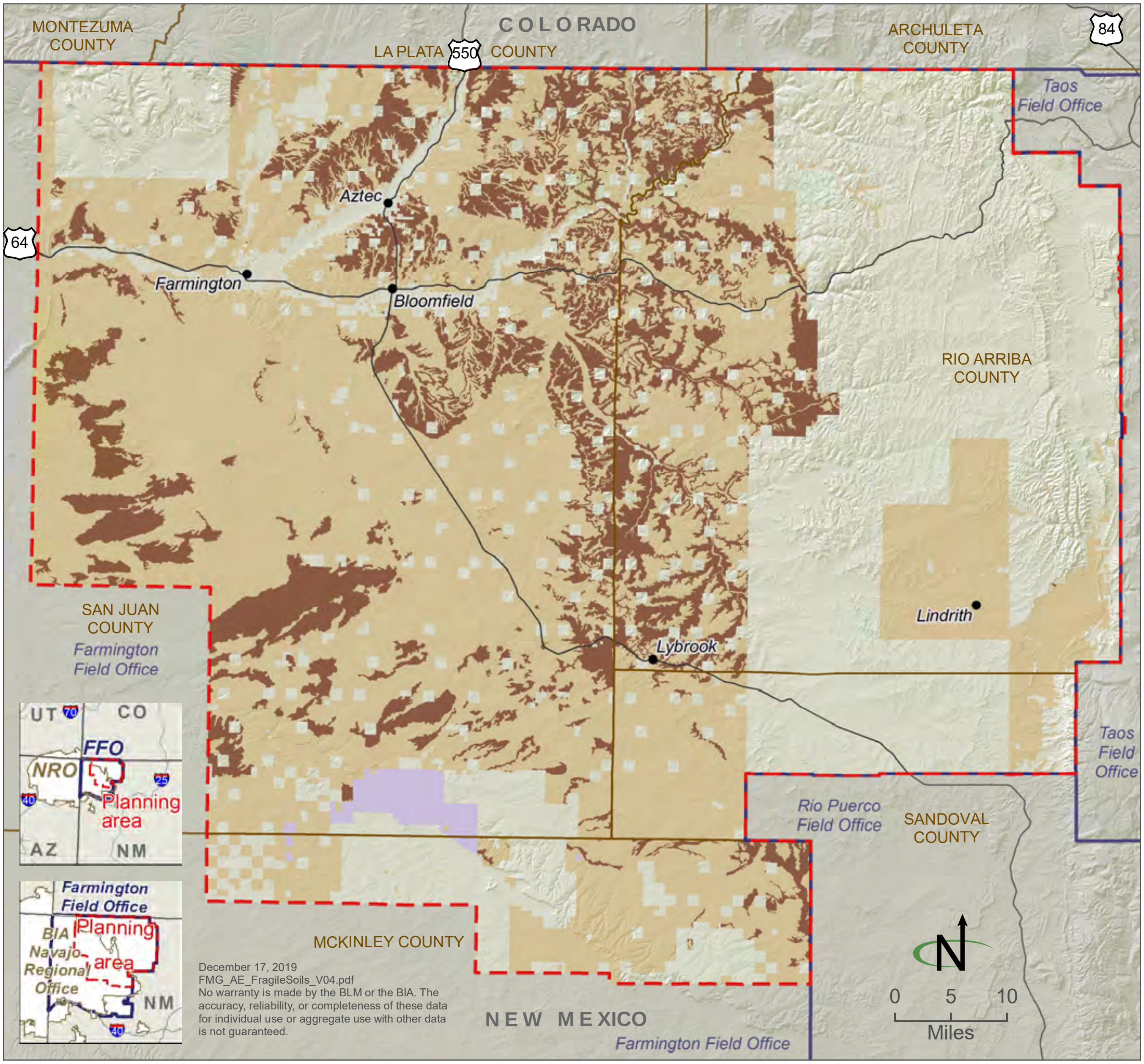
Wetlands are areas that lie transitionally between terrestrial and aquatic ecosystems, typically where the water table is at or near the surface, or where land is covered by shallow water. Riparian areas are plant communities that are affected by surface and sub-surface hydrologic features, e.g., rivers, streams, lakes, or drainage ways. Springs are concentrated discharges of water flowing from an aquifer to the Earth's surface.



Source: BLM GIS 2020

- Wetland
- Riparian area
- Spring
- BLM and BIA decision area
- Planning area
- National Park Service
- Field office boundary

Figure 3-10
Fragile Soils

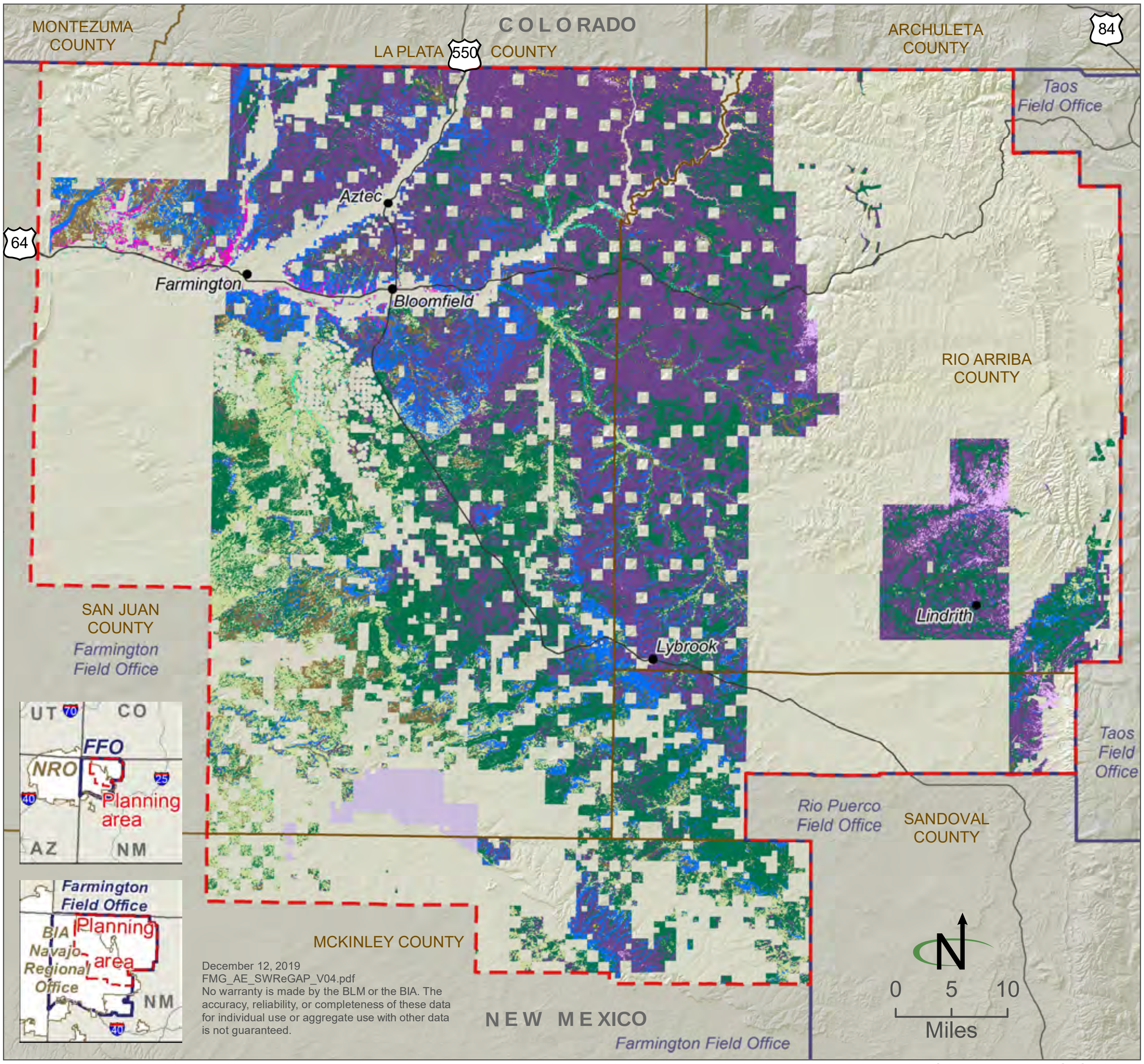


Source: BLM GIS 2020

Fragile soils
BLM and BIA decision area
Planning area
National Park Service
Field office boundary

Figure 3-11
Vegetation Communities

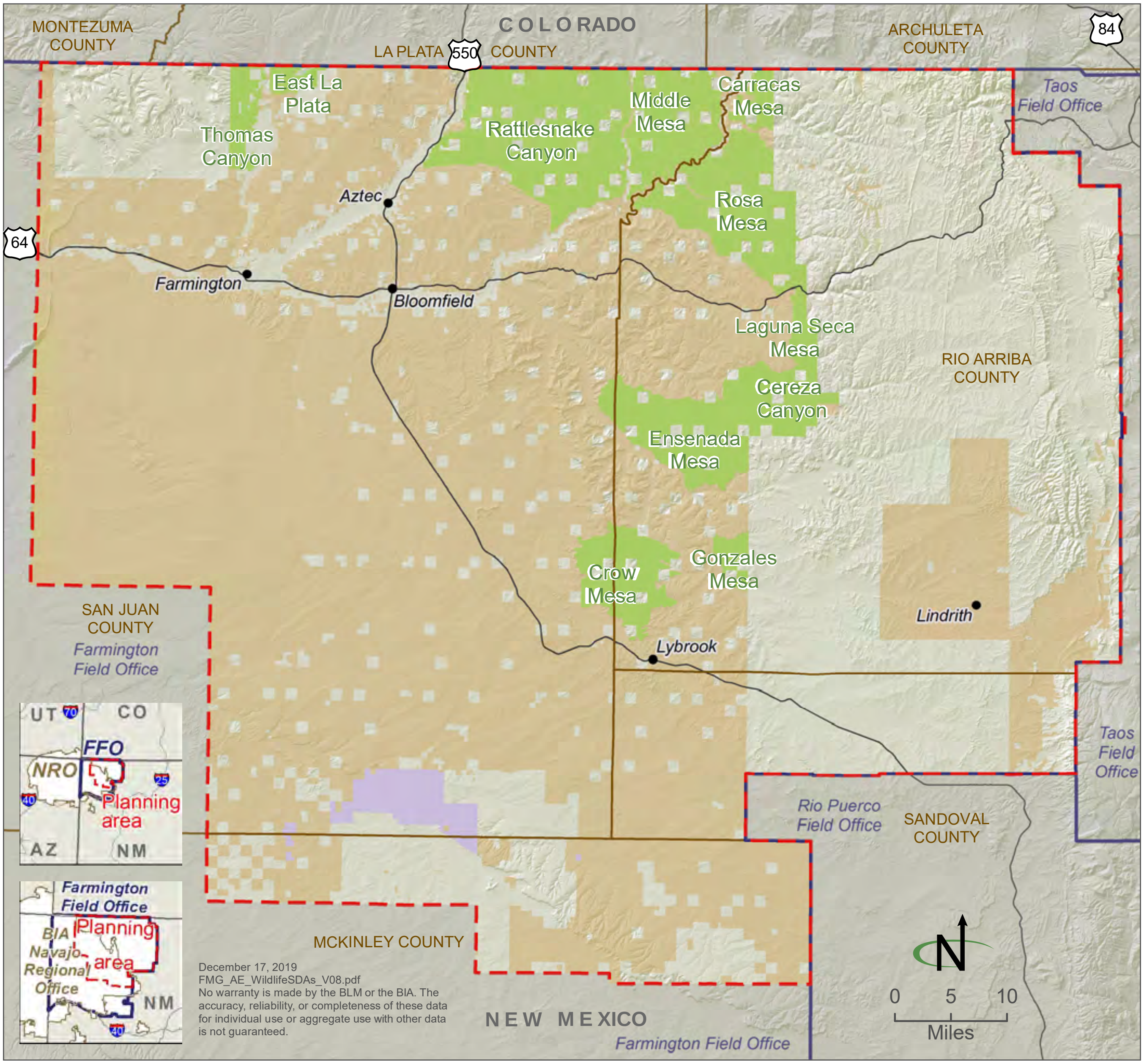
The planning area contains nine plant community types. The BLM derived the vegetation communities from the combination of Southwest Regional Gap Analysis Project (SWReGAP) data and ecological site descriptions (ESDs). Vegetation communities are displayed on the BLM decision area.



Source: BLM GIS 2020

- Pinyon-juniper
- Sagebrush grassland
- Grassland
- Badlands
- Greasewood
- Ponderosa pine-mixed conifer
- Saltbush shadscale/winterfat
- Riparian-wetland
- Oak woodland
- Planning area
- National Park Service
- Field office boundary

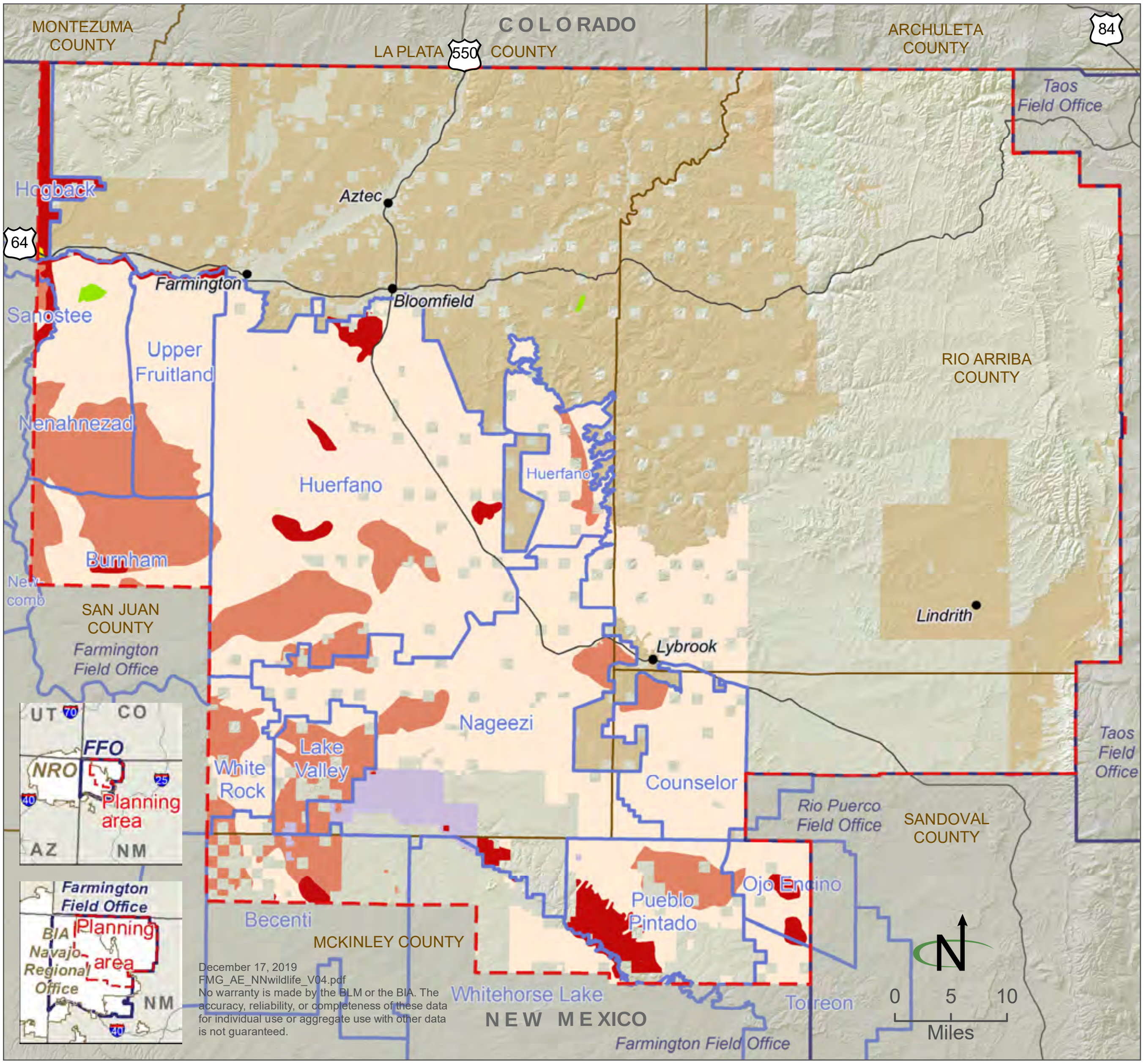
Figure 3-12
Wildlife SDAs



Source: BLM GIS 2020

Wildlife area SDA
BLM and BIA decision area
Planning area
National Park Service
Field office boundary

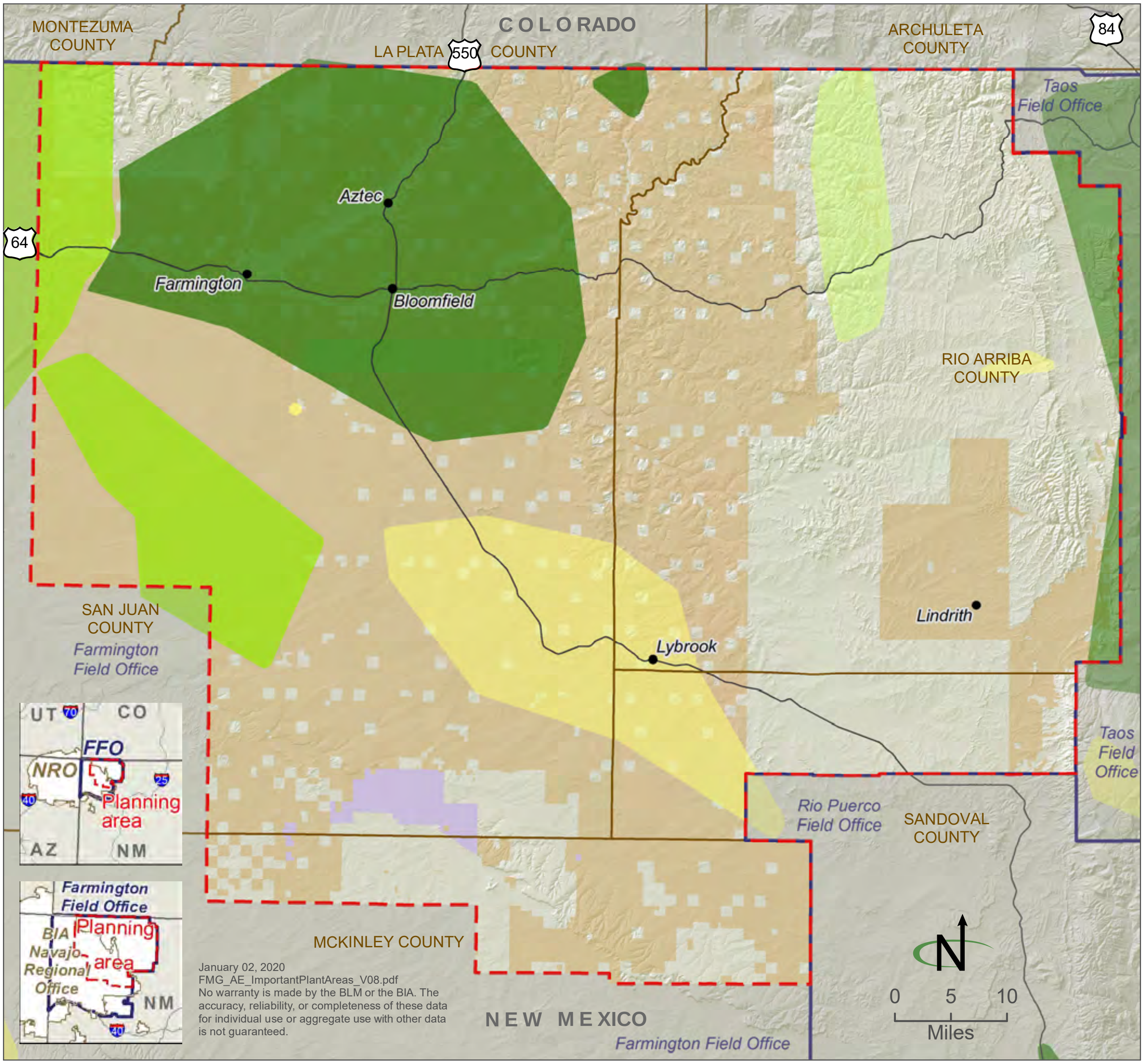
Figure 3-14
Navajo Nation Wildlife Areas



Source: BLM GIS 2020

- High Sensitivity
- Moderate Sensitivity
- Low Sensitivity
- Community Development
- Recreational Area
- BLM and BIA decision area
- Planning area
- National Park Service
- Field office boundary
- Navajo Nation Chapter

Figure 3-15
Important Plant Areas

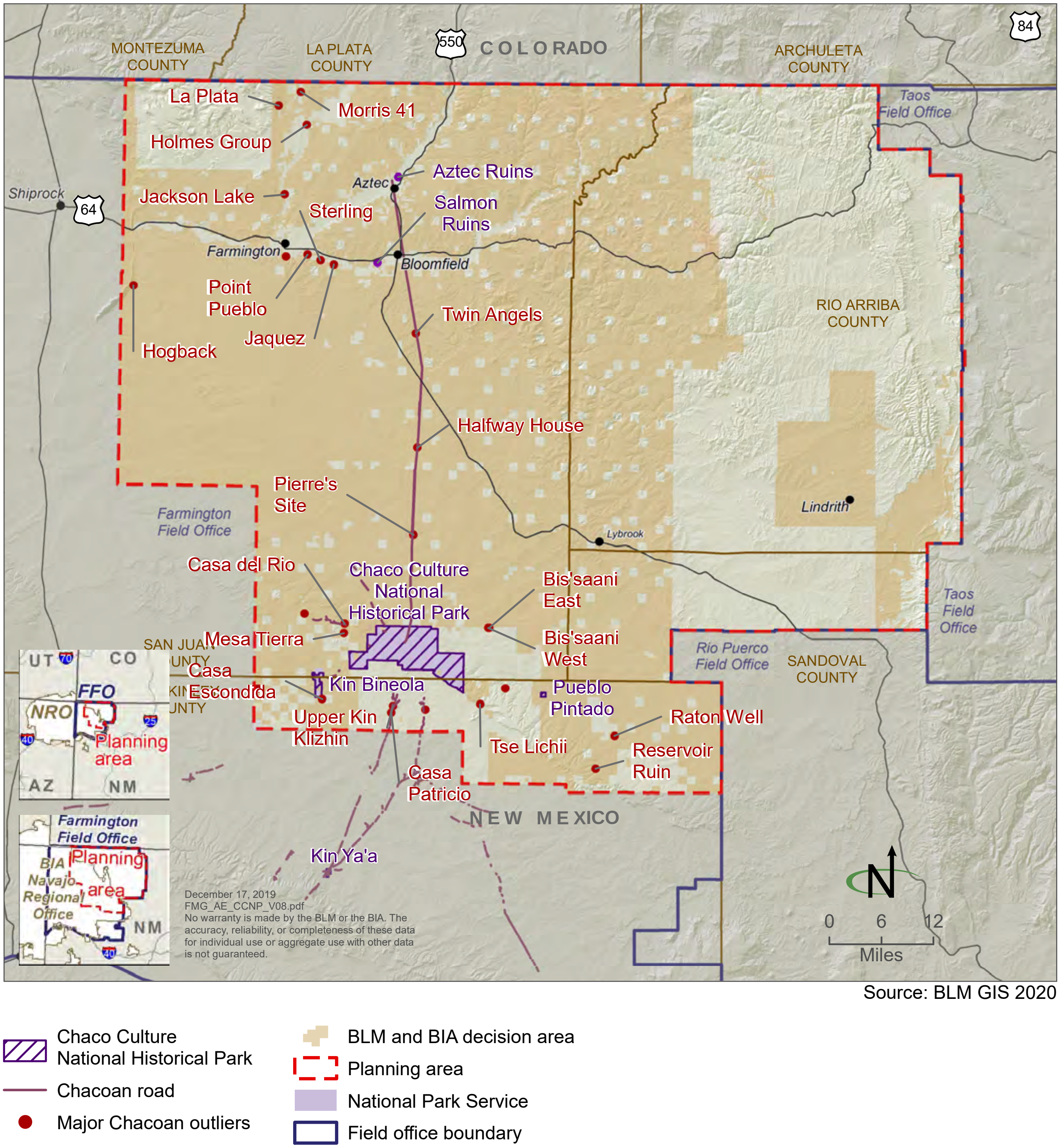


Source: BLM GIS 2020

Biodiversity Rank
- B1 - Outstanding
- B2 - Very high
- B3 - High
- B4 - Moderate

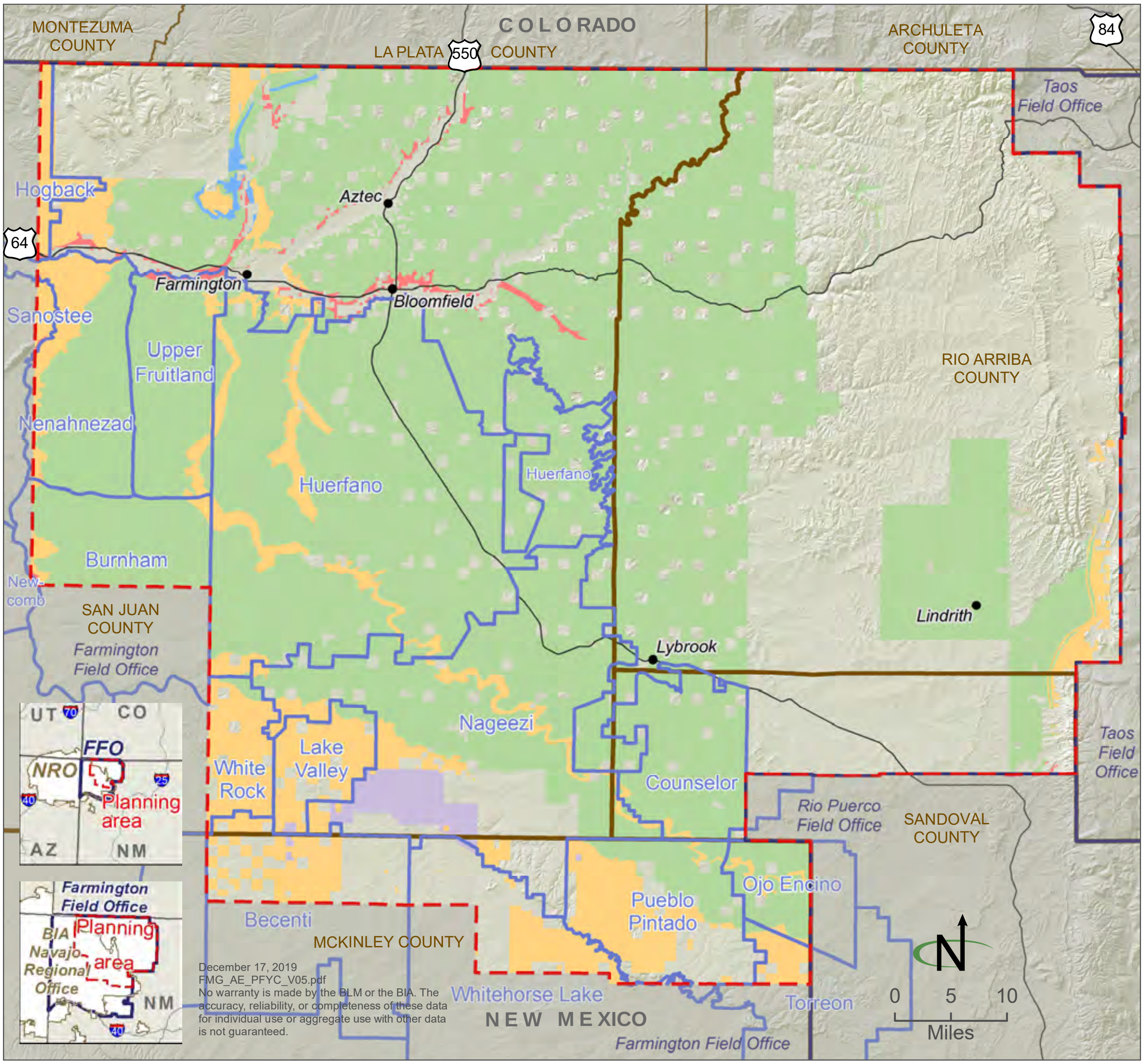
- BLM and BIA decision area
- Planning area
- National Park Service
- Field office boundary

Figure 3-17
NPS, UNESCO, and Select Chacoan Roads and Great Houses



Source: BLM GIS 2020

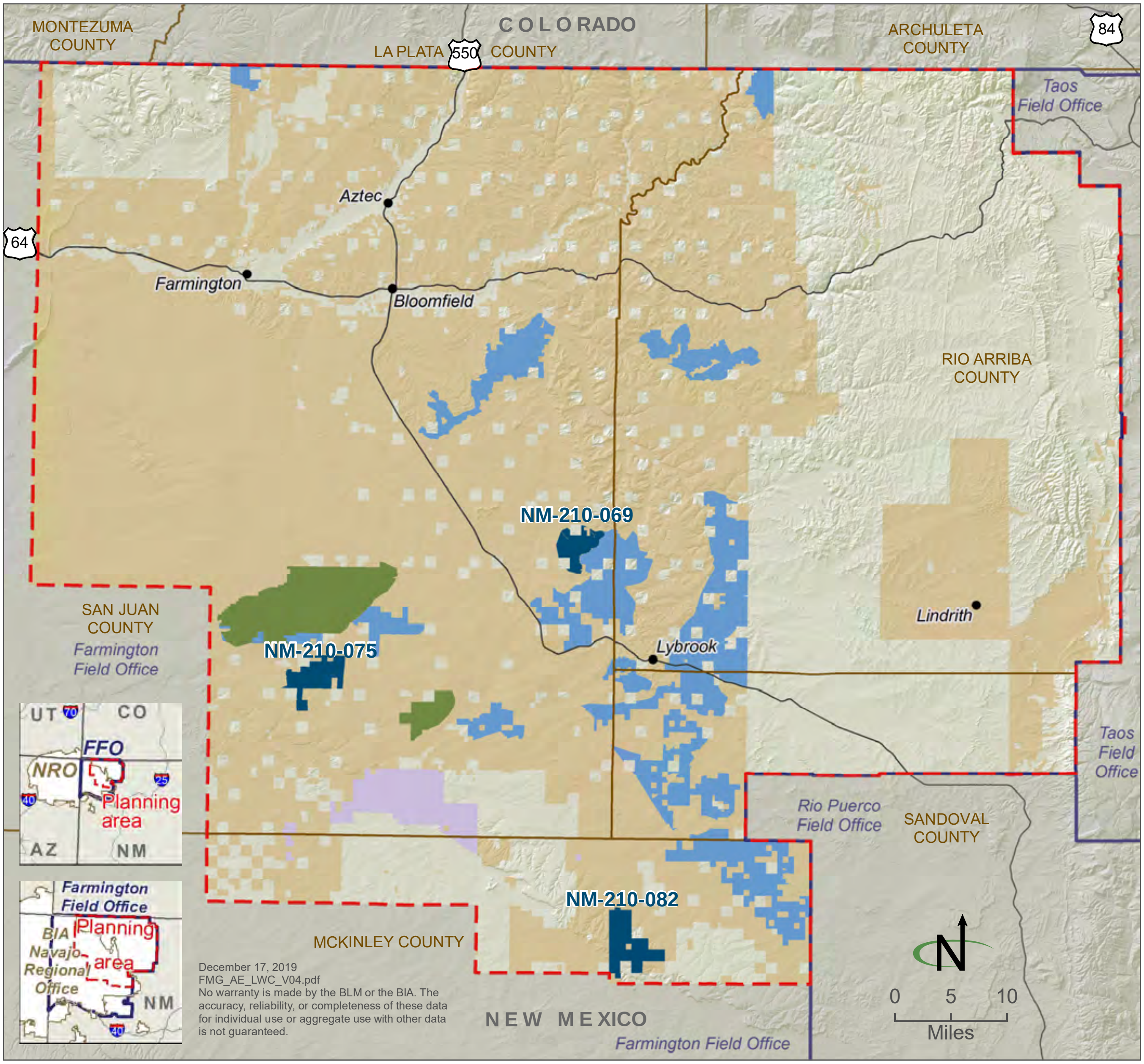
Figure 3-18
Potential Fossil Yield Classification



Source: BLM GIS 2020

PFYC 5	Very high fossil occurrence		Planning area
PFYC 4			National Park Service
PFYC 3			Field office boundary
PFYC 2			Navajo Nation Chapter
PFYC 1	Very low potential for recognizable fossils		

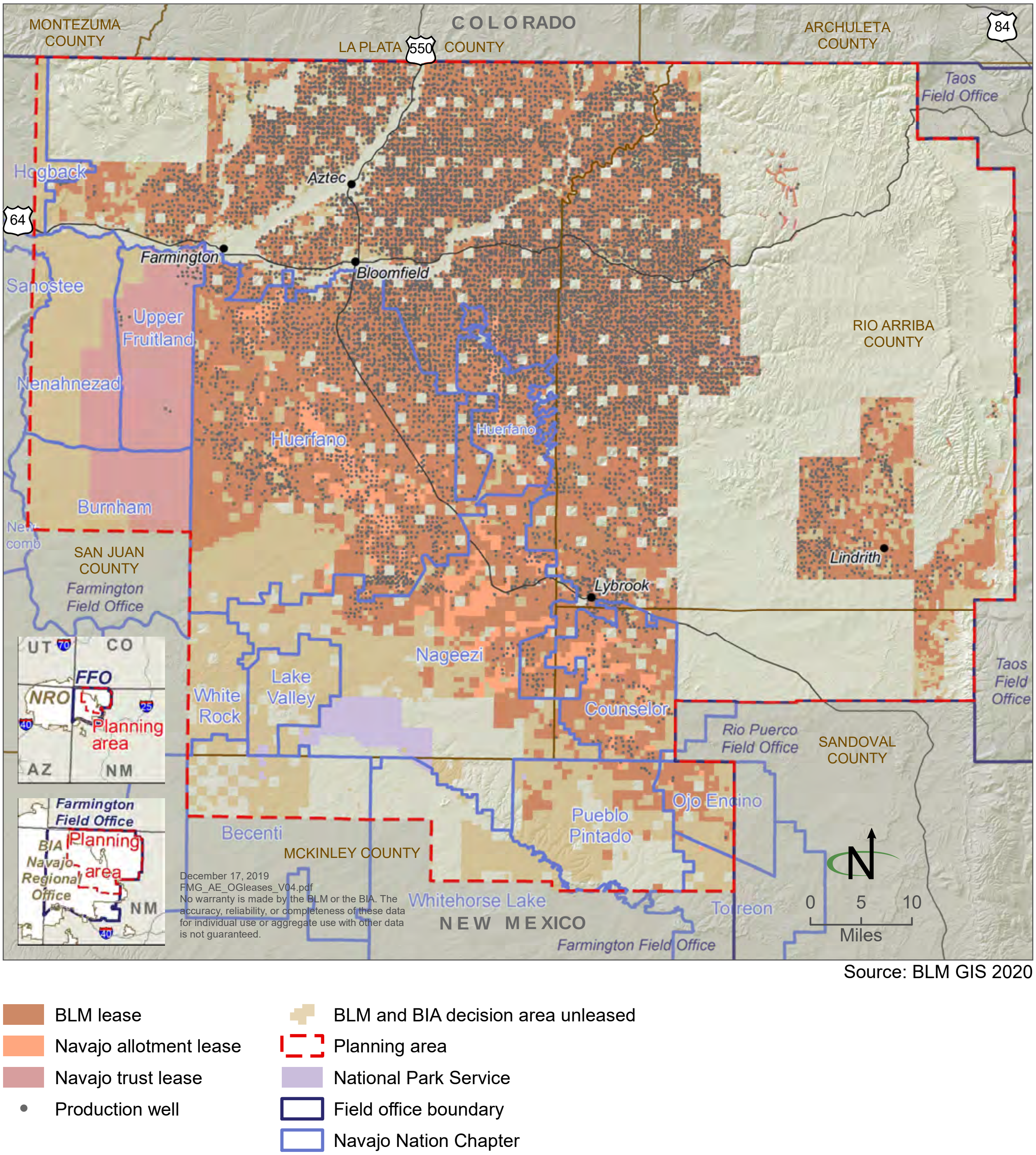
Figure 3-19
BLM Units Inventoried for Wilderness Characteristics



Source: BLM GIS 2020

- Unit with wilderness characteristics
- Unit without wilderness characteristics
- Existing wilderness area
- BLM and BIA decision area
- Planning area
- National Park Service
- Field office boundary

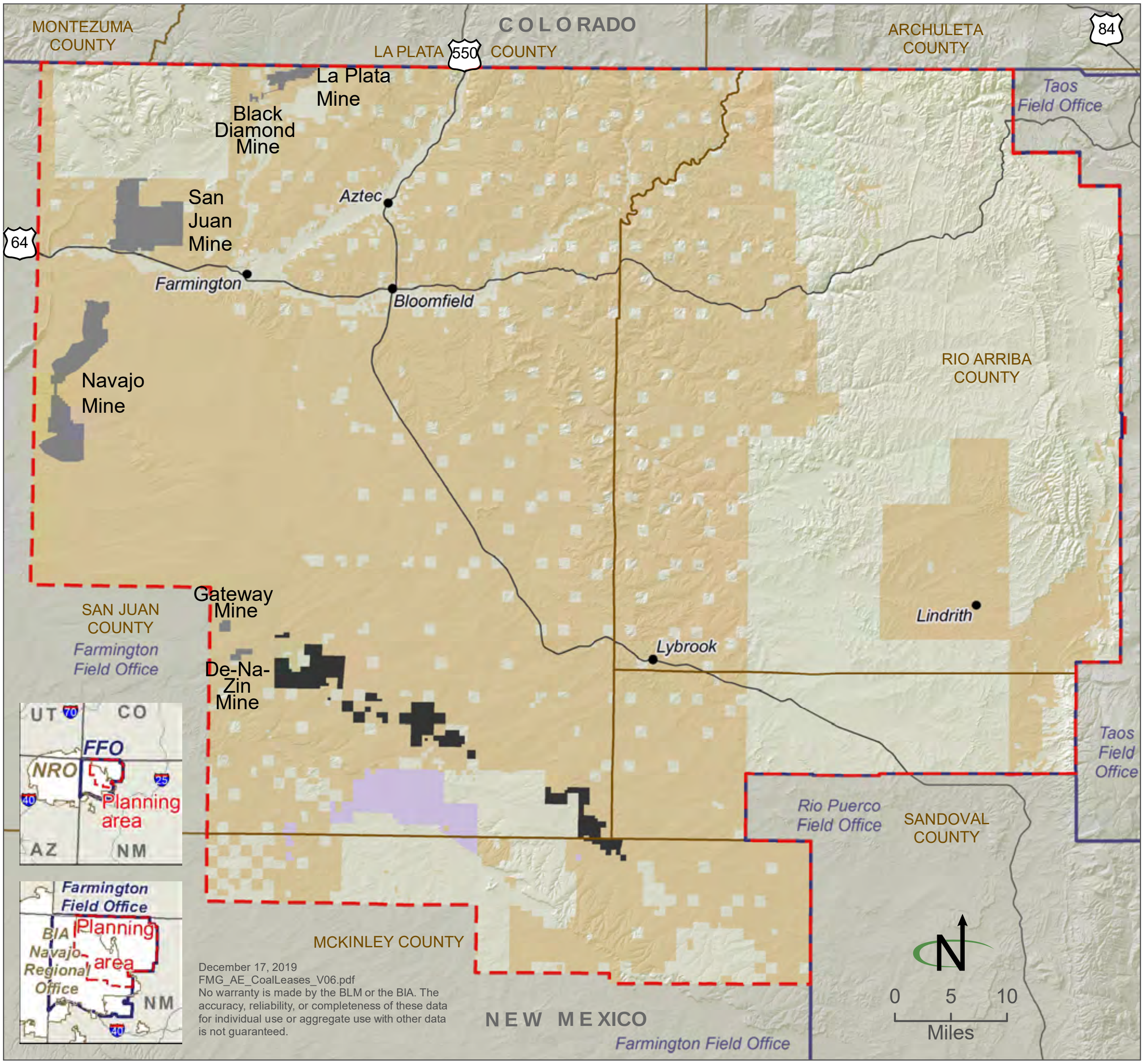
Figure 3-20
Oil and Gas Leases



Source: BLM GIS 2020

Figure 3-21
Coal

Leasable minerals are those minerals or materials designated as leasable under the Mineral Leasing Act of 1920. Coal is currently the only solid leasable mineral developed in the planning area.

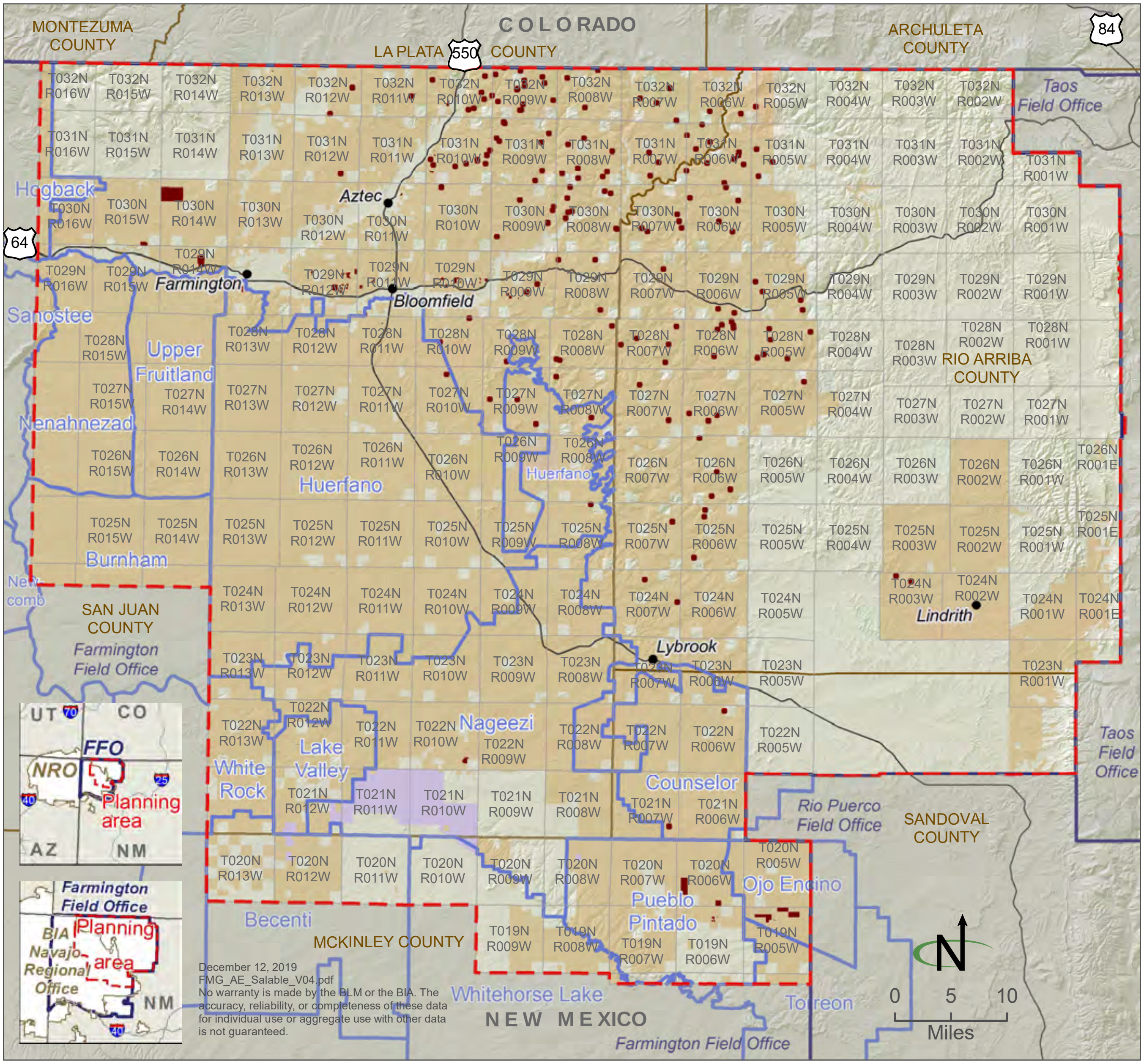


Source: BLM GIS 2020

Coal permit boundary
Preference right lease application
BLM and BIA decision area
Planning area
National Park Service
Field office boundary

Figure 3-22
BLM Salable Minerals and
BIA Nonenergy Solid Minerals

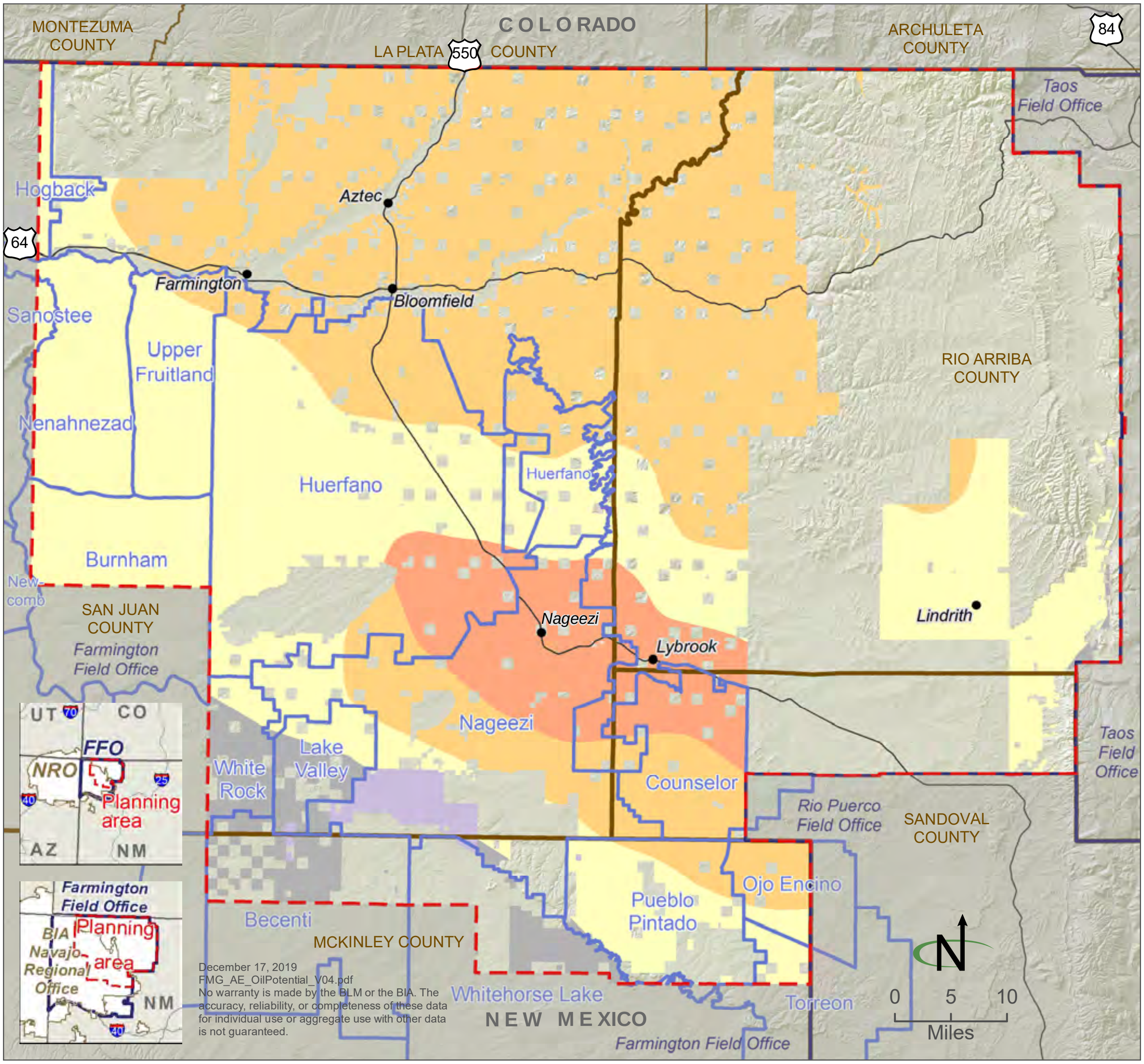
Salable minerals include common varieties of mineral materials, such as soil, sand and gravel, stone, pumice, pumicite, and clay that can be acquired under the Materials Act of 1947, as amended.



Source: BLM GIS 2020

- Gravel or rock pit
- Rock pit
- BLM and BIA decision area
- Planning area
- National Park Service
- Field office boundary
- Navajo Nation Chapter

Figure 3-23
Oil and Gas Development Potential 2018-2037

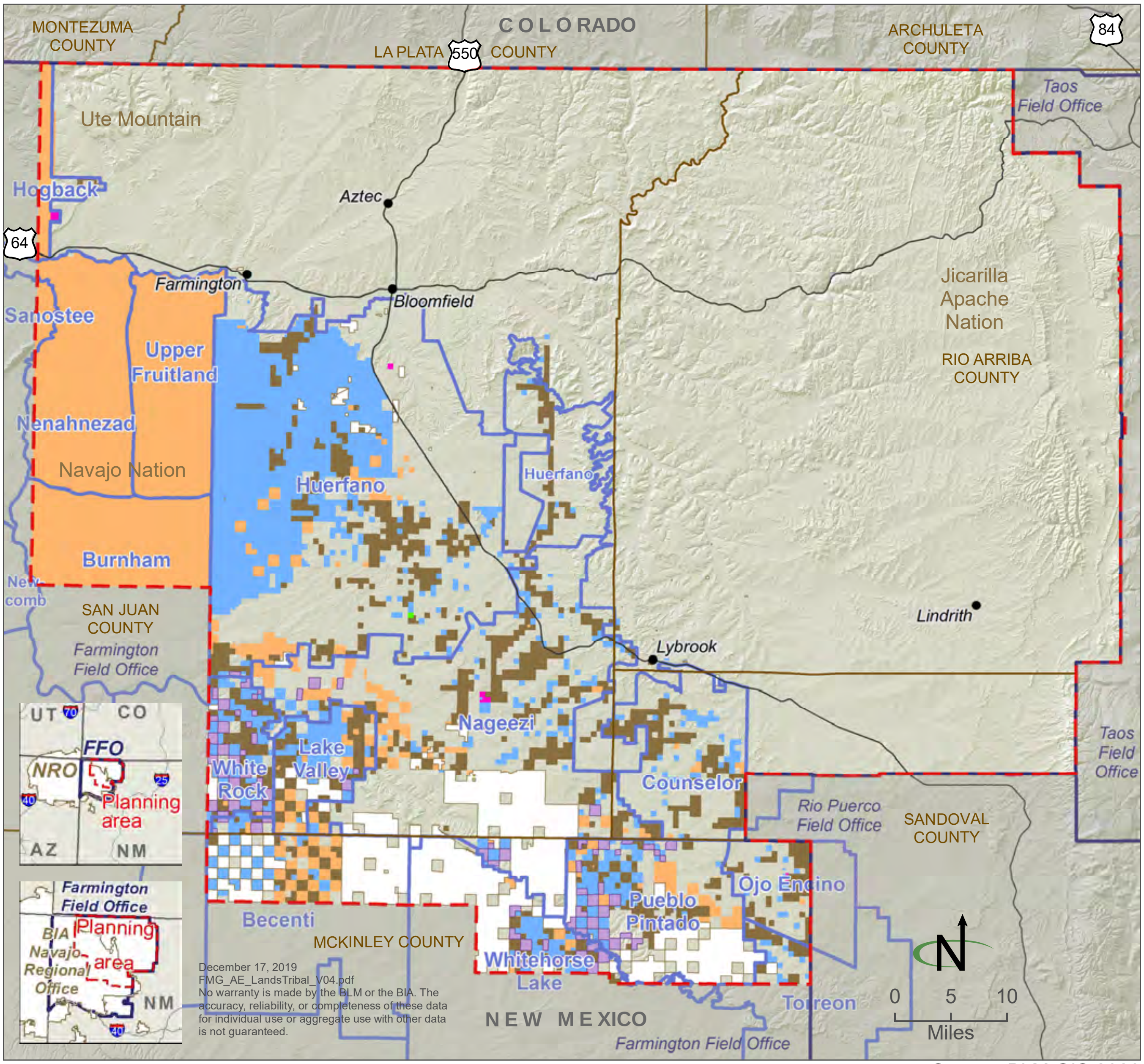


Source: BLM GIS 2020

Development Potential
- High
- Medium
- Low
- Negligible

- Planning area
- National Park Service
- Field office boundary
- Navajo Nation Chapter

Figure 3-24
BIA Surface and Subsurface Management

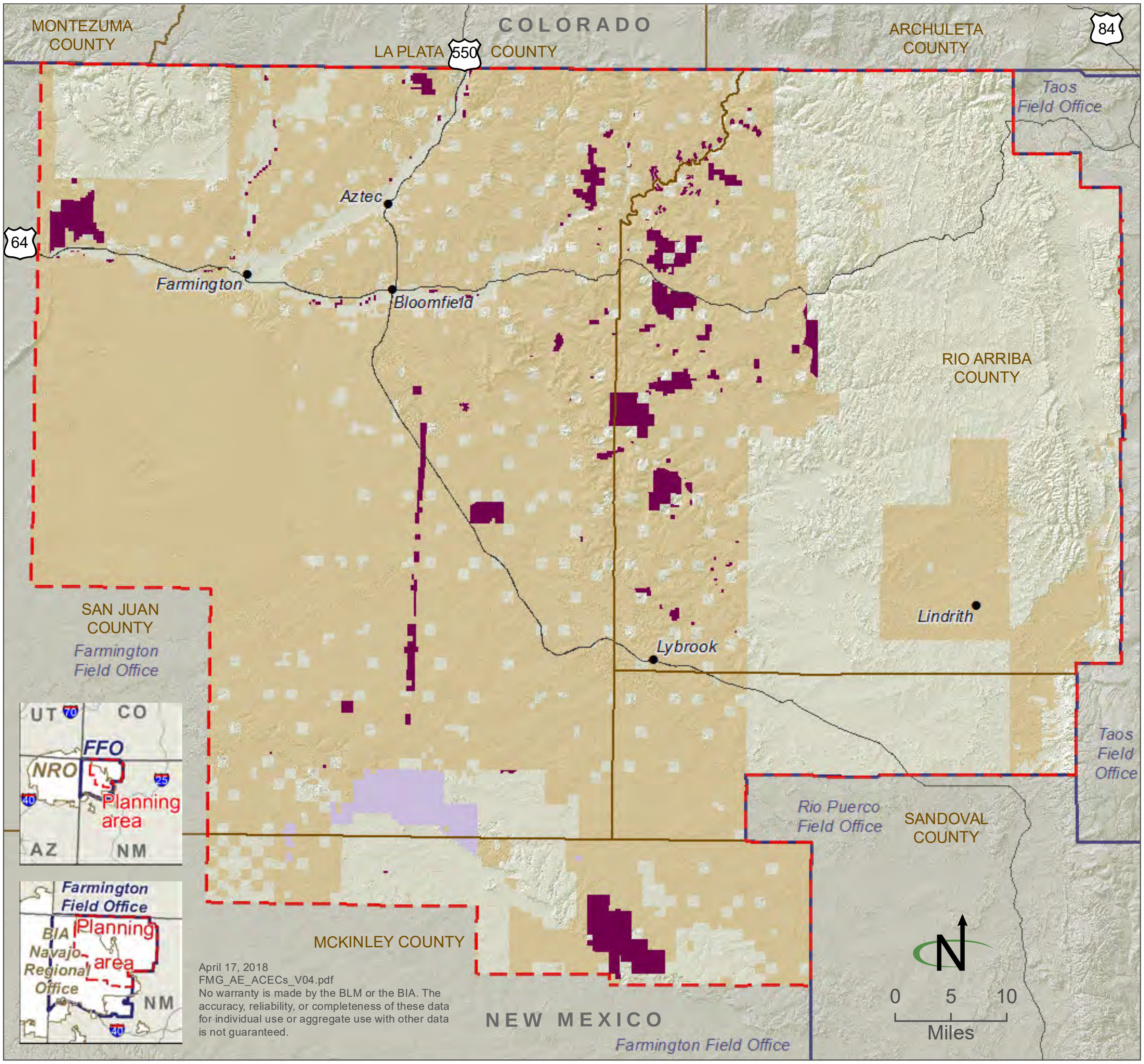


Source: BLM GIS 2020

- Navajo Tribal fee (private land)
- PLO 2198: Public land order which withdrew land from public domain for a proposed reservation adjustment, BIA has administrative management, Navajo Nation has a vested interest
- Other PLO/BIA-administered withdrawn land
- Navajo trust surface land and Navajo trust subsurface mineral estate
- Navajo trust surface land and federal mineral estate
- Navajo allotment surface land and Navajo allotment subsurface mineral estate
- Navajo trust surface land and Navajo allotment subsurface mineral estate
- Planning area
- Field office boundary
- Navajo Nation Chapter

Figure 3-25
BLM Areas of Critical Environmental Concern

Areas of Critical Environmental Concern (ACECs) are land designations that highlight areas that require special management attention, and are contingent on both relevance and importance criteria. This criteria refers to the significance of important historical, cultural, and scenic values, fish and wildlife resources, additional natural systems and processes, as well as actions to protect human life and safety from natural hazards.

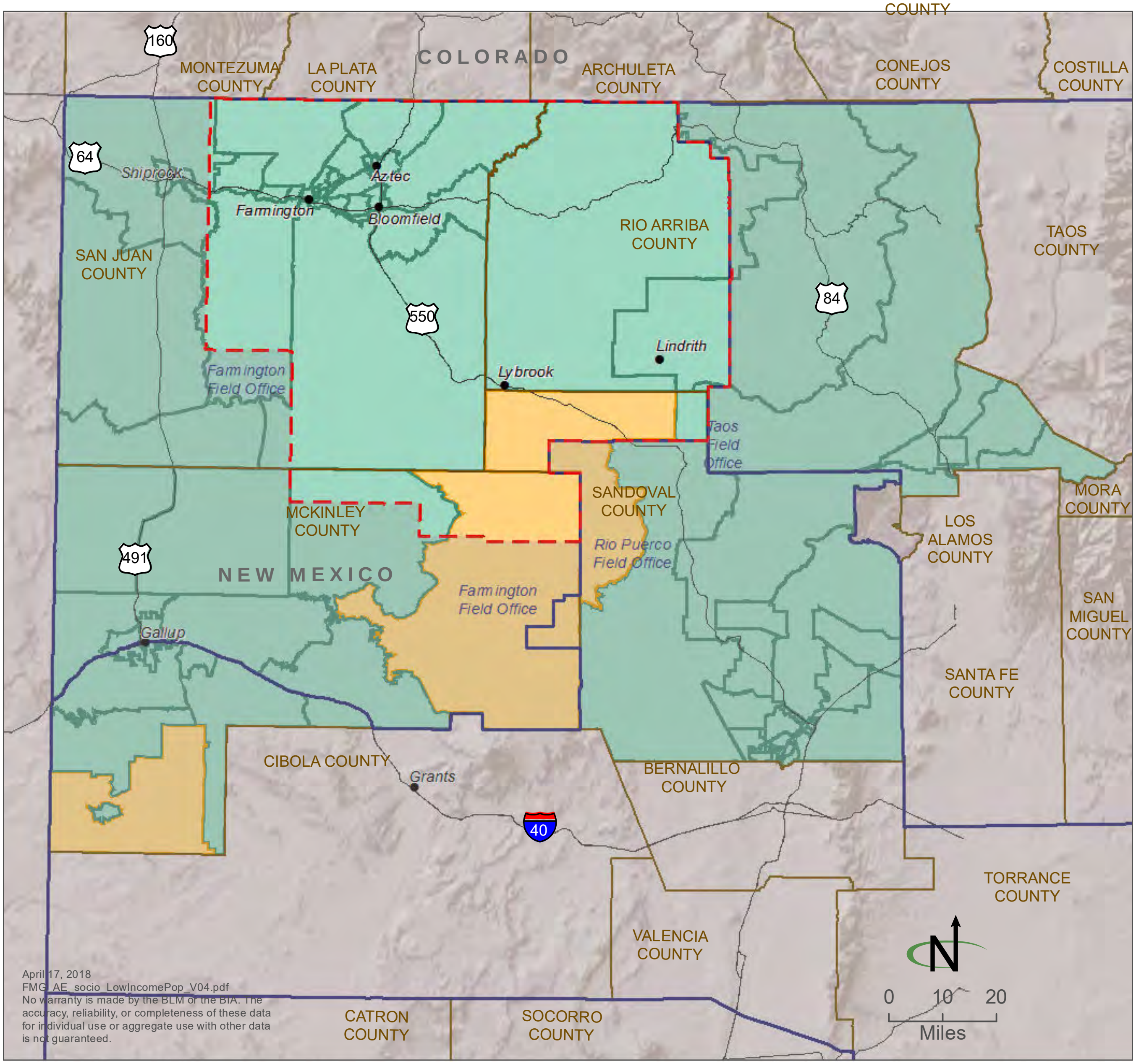


Source: BLM GIS 2017

- Areas of Critical Environmental Concern (ACECs)
- BLM and BIA decision area
- Planning area
- National Park Service
- Field office boundary

Figure 3-26
Low-Income Populations by Census Tract

A low-income population is determined based on annual statistical poverty thresholds developed by the US Census Bureau. In 2012, poverty level is based on total income of $11,720 for an individual and $23,283 for a family of four.

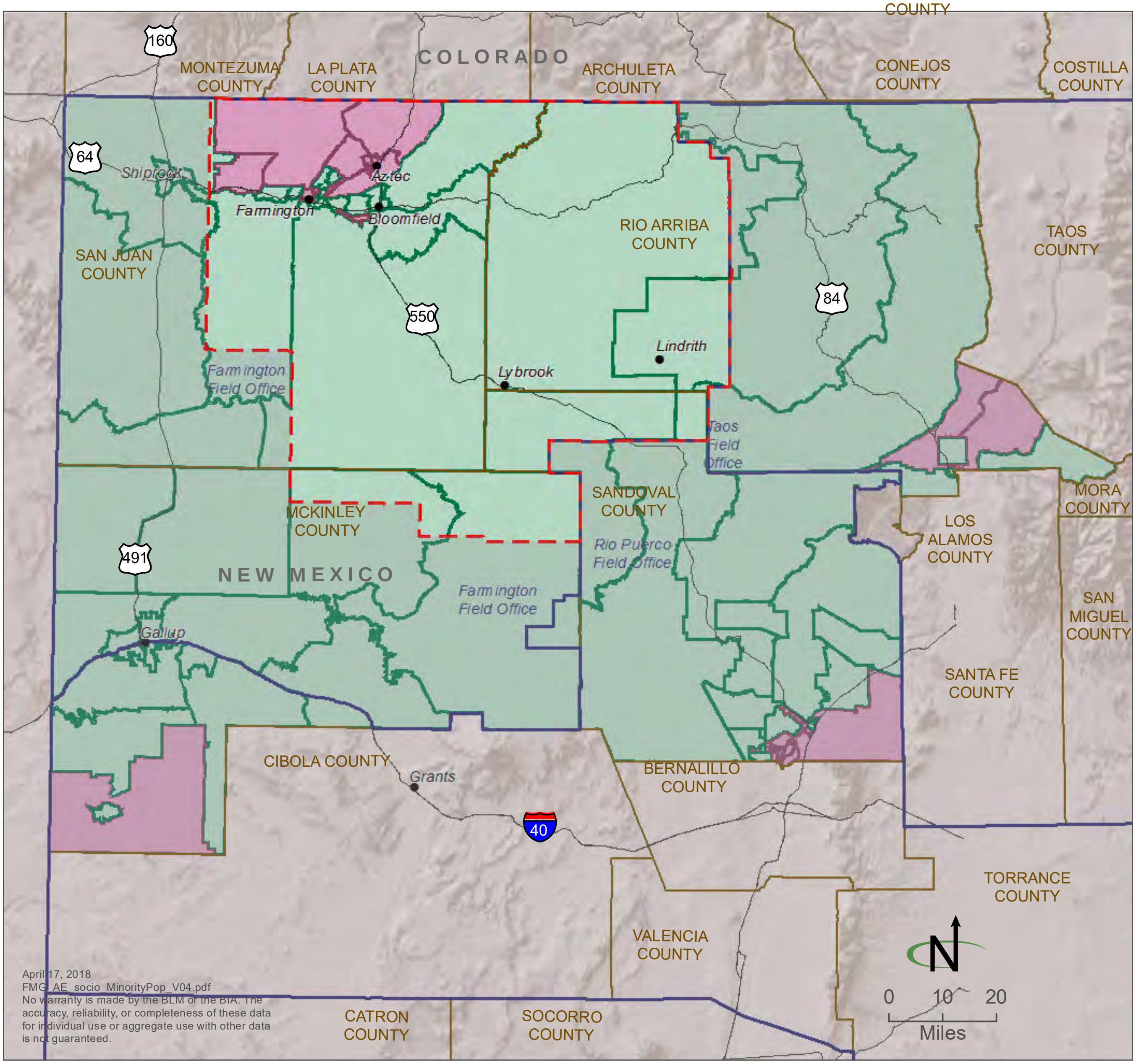


Source: BLM GIS 2017, US Census Bureau 2012b, 2014

Greater than 50% of individuals live below the poverty line
Less than 50% of individuals live below the poverty line
Planning area
Field office boundary

Figure 3-27
Minority Populations by Census Tract

A minority population area is defined as either an area in which the combined population of all minority groups exceeds 50 percent of the total population, or an area in which the percentage of all minority groups is meaningfully greater than the percentage of the minority population in the broader region.

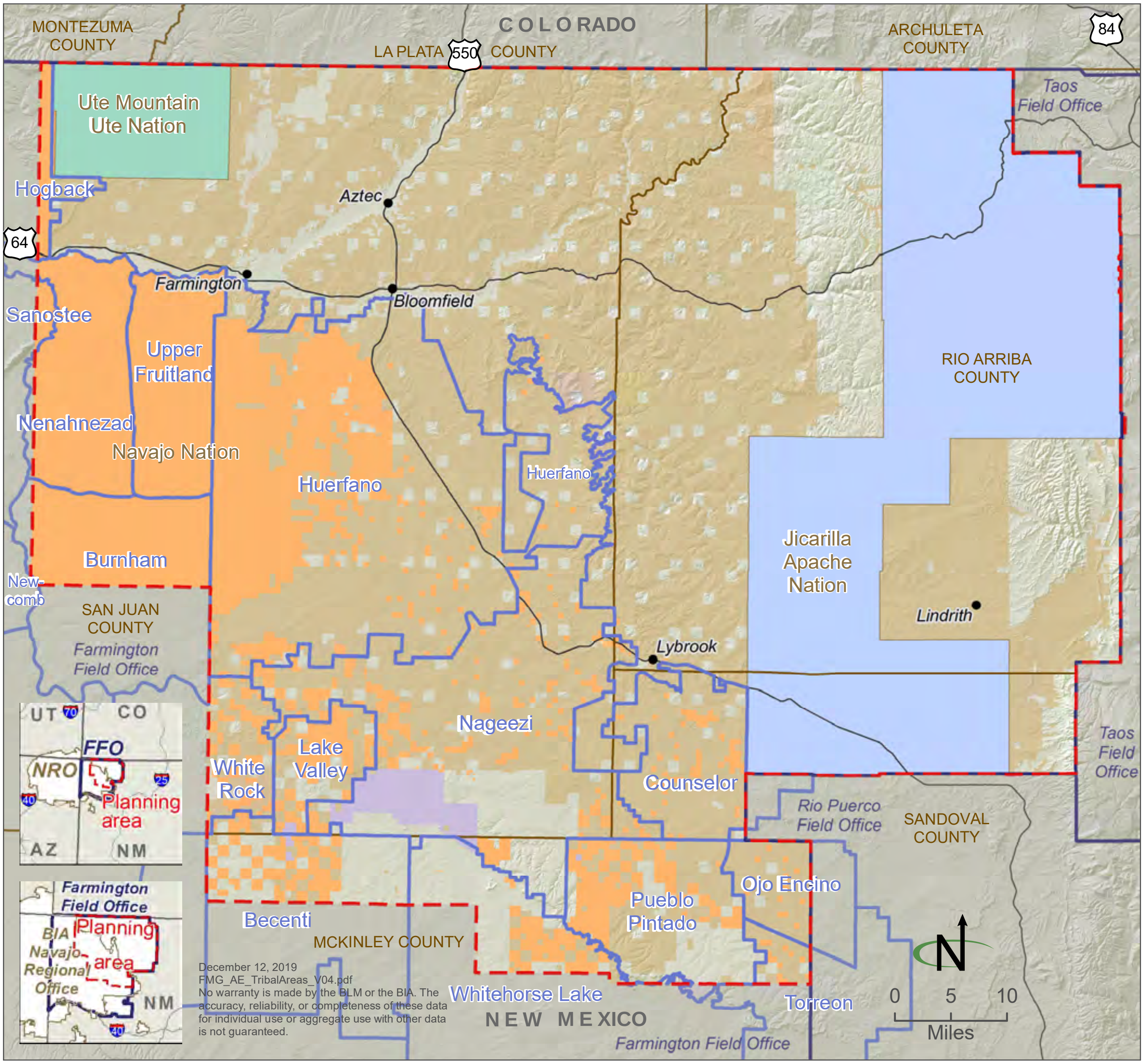


Source: BLM GIS 2017, US Census Bureau 2012b, 2014

- Greater than 50% of the population identifies as a minority race
- Less than or equal to 50% of the population identifies as a minority race
- Planning area
- Field office boundary

Figure 3-28
Tribal Nations

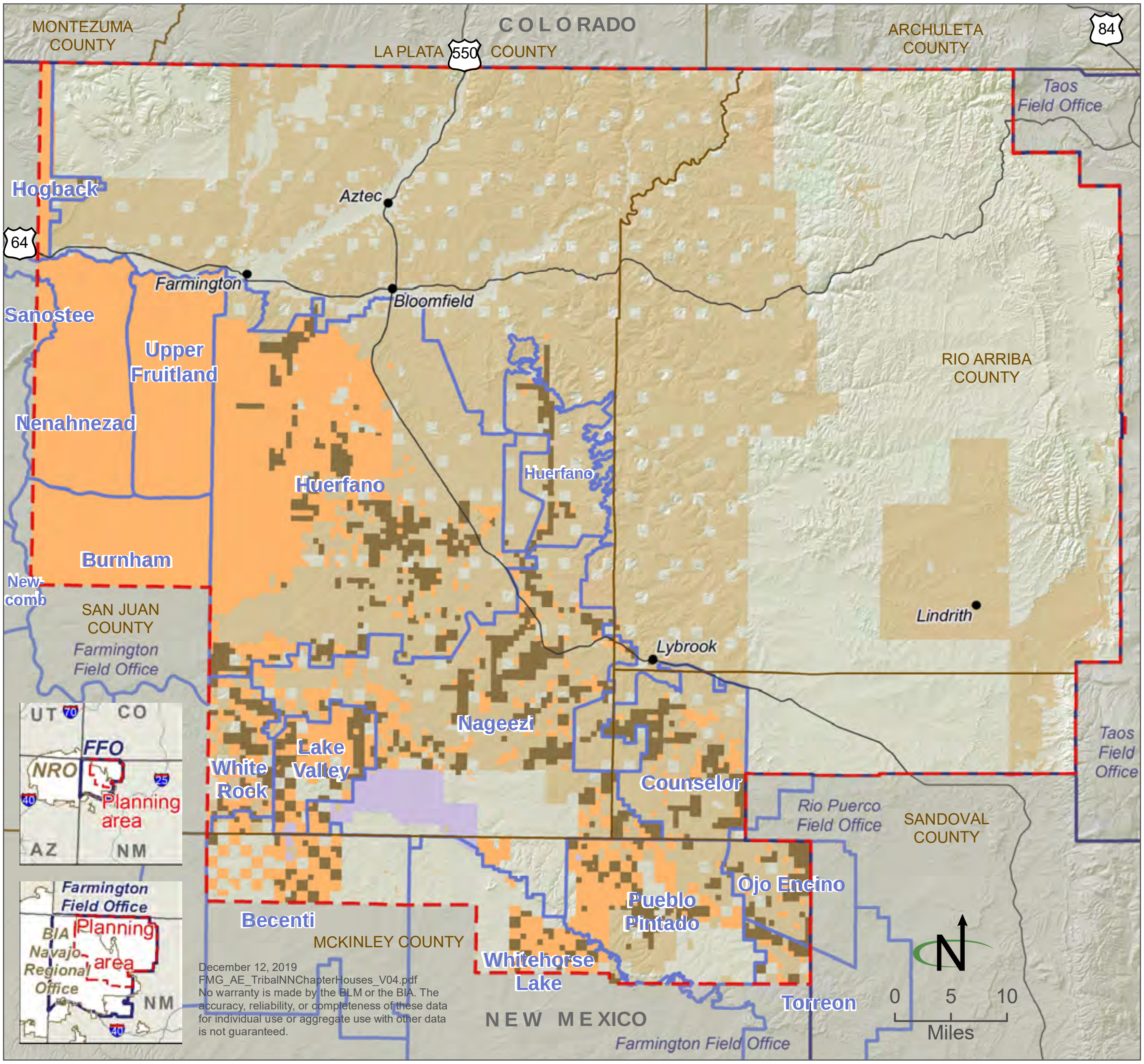
Three tribal governments have reservations in the planning area: the Jicarilla Apache Nation, the Navajo Nation, and the Ute Mountain Ute Nation.



Source: BLM GIS 2020

Navajo Nation	BLM and BIA decision area
Jicarilla Apache Nation	Planning area
Ute Mountain Ute Nation	National Park Service
	Field office boundary
	Navajo Nation Chapter

Figure 3-29
Navajo Nation Chapters



Source: BLM GIS 2020

Appendix B
Best Management Practices

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TABLE OF CONTENTS

Section Page

ACRONYMS AND ABBREVIATIONS

Acronym	Full Phrase
BIA	United States Department of the Interior, Bureau of Indian Affairs
BLM	United States Department of the Interior, Bureau of Land Management
BMP	best management practice
FFO	Farmington Field Office
ROW	right-of-way

Appendix B. Best Management Practices

BMPs are a suite of site-specific techniques that guide, or may be applied to, management actions to aid in achieving desired outcomes, such as resource protection. They are no requirements for operators or ROW applicants. This appendix details BMPs that are encouraged for use by oil and gas operators and ROW applicants in the BLM and BIA decision areas. Additional BMPs relevant to oil and gas development in New Mexico can be found in the following source:

NMOCD (New Mexico Oil Conservation Division). 2000. Pollution Prevention Best Management Practices for the New Mexico Oil and Gas Industry. Santa Fe, New Mexico. Internet website: http://www.emnrd.state.nm.us/OCD/documents/2000PollutionPreventionBMPs.pdf.

B.1 BUREAU OF LAND MANAGEMENT

B.1.1 General BMPs

- Inspect and clean all surface-disturbing equipment before bringing it onto public lands.
- Maintain inspection forms; the BLM Authorized Officer may request to see them at any time.
- Use only certified noxious weed-free seed, hay, straw, mulch, or other vegetation material transported and used on public land for site stability, rehabilitation, or project facilitation.
- Place all linear disturbances in corridors.
- Use surface pipelines to cross undisturbed areas.
- Install pipelines using boring or other non-surface-disturbing technologies, rather than open trenching.
- Implement interim reclamation on well pads and road surfaces leading to the well pads within 6 months of well completion. Standard interim and final reclamation procedures will be sufficient.
- Complete final reclamation to restore the landform and native plant community. Use noxious weed-free fill dirt if it is brought onto public lands. Final reclamation will follow interim and final reclamation procedures.
- Place multiple wells on a single pad to reduce impacts where feasible.
- Use directional or horizontal drilling where feasible.
- Use existing infrastructure, such as pipelines and roads, to reduce impacts.
- Install pipelines to follow existing disturbance, where feasible, which may include roads, utility ROWs and pipelines, and corridors, to reduce disturbance and minimize habitat fragmentation.
- Use physical barriers or other methods to keep unauthorized roads from being developed.
- Require ROW holders to consult with applicable transportation and road departments of Tribal, state, and local agencies regarding permits and to limit impacts on road networks.

In addition, new technology to reduce or capture emissions is encouraged. Liquids-gathering systems and centralized off-site production facilities may be required to reduce impacts on communities, wildlife, and other resources.

B.1.2 Air Quality

- There should be a maximum of 90 days between well pad construction and well spud, unless circumstances warrant a longer period.

B.1.3 Cultural Resources

- Require gates on new roads that lead to sensitive cultural sites.

- Consult with Tribes with a cultural affinity for the area to avoid or minimize impacts on traditional plant gathering and offering areas and sacred viewsheds.
- Unless it would lead to an unresolved impact on other cultural resources, operators will collocate authorized roads, pipelines, and ROWs in the foreground of the following:
  - Chacoan roads and outliers
  - Traditional cultural properties
  - Other Chacoan sites
  - Navajo sites with high visitation
  - Prominent landforms

B.1.4 Paleontological Resources

- Use gates, temporary or permanent fencing, data recovery, and monitoring to protect paleontological resources.

B.1.5 Upland Vegetation and Soils

- Require that well pads and ROWs avoid range plots and improvements, so as not to degrade the plot or improvement, which would take away from the intent of the improvement.
- Avoid vegetation trend and monitoring plots to ensure that past, present, and future monitoring data are not lost. Avoid rangeland improvements, where feasible.
- Avoid placement of infrastructure in fragile soils.
- Avoid placement of infrastructure on slopes greater than 15 percent.

B.1.6 Water Resources

- Use closed-loop systems to reduce the risk of spills and contamination of water and soils.
- Consider options that reduce water use in fracturing fluid.

B.1.7 Wildlife and Migratory Birds

- Avoid harassing all wildlife at well pads, facilities, and associated infrastructure.

B.1.8 Special Status Species

- In areas identified as potential or occupied special status species habitat, inventory and pursue habitat conservation areas for special status plant species.
- In special status species habitat, use the best available information and techniques to address impacts. (Note: The FFO will coordinate with the BLM New Mexico State Office and the New Mexico Forestry Division to determine best techniques.)
- Consult FFO for latest internal policy regarding special status species.
- Require that surveys be undertaken for special status species where habitat or colonies are not specifically delineated.
- Restrict development within 100 meters (328 feet) of occupied habitat.
- Adjust the location of the disturbance to eliminate impacts, including habitat fragmentation/modification, to suitable habitat for special status plants.
- Avoid ground-disturbing activities within 50 meters (165 feet) of an active Gunnison's prairie dog colony boundary.
- Minimize the area of disturbance.
- Use dust abatement measures to reduce disturbance of special status species.
- Use signs, fencing, and other deterrents to reduce possible human disturbance of special status species.

- Require specialized reclamation procedures (e.g., separating soil and subsoil layers with barriers to reclaim in the correct order and additional emphasis on forbs in seed mixes to promote pollinator habitat).
- Establish long-term monitoring of the species and/or habitat.
- Employ a qualified, independent third-party contractor to provide general oversight and assure compliance with project terms and conditions.
- Use nonnative or invasive species monitoring and control. These measures also may be applied to projects near suitable habitat that may hold special value or to provide protection to suitable habitat that may allow for species' expansion.
- Collect seeds or other genetic material (according to Center for Plant Conservation protocols) to preserve any affected special status species populations. Material can be placed in long-term storage, or seed can be used for restoration projects.
- Regarding the National Reserve of Native Seed Mixes identified in the strategy, work with Seeds of Success and use the National Seed Strategy to collect those species most important for pollinators locally, and increase their availability in plant materials programs.
- Plan the timing and location of pesticide applications to avoid impacts on pollinator populations.
- Use pesticides that are harmful to pollinators only when pollinators would not be affected.

B.2 Bureau of Indian Affairs

B.2.1 General Fluid Mineral BMPs

- Before the BIA grants any new lease, the lessee should conduct an inventory of any noxious weeds or invasive species. If any noxious weeds or invasive species are identified, the lessee should implement a program to control the identified weeds and their potential to spread to other areas. The guidelines for this control program will follow those put forth in the Navajo Nation Integrated Weed Management Plan, which include the following general treatments:
  - Clean tires, boots, and equipment when leaving infested areas to prevent weed transport to new areas.
  - Manually control weed populations, including using hand tools to cut, clear, or prune herbaceous or woody species. Manual treatments involve cutting undesirable plants above ground level; pulling, grubbing, or digging out root systems to prevent sprouting and regrowth; and removing competing plants around desired species. Implement manual techniques in smaller areas, but they are not effective or feasible in larger weed infestations. Implement manual techniques in sensitive areas, such as riparian areas, areas where burning or herbicide treatments are not appropriate, areas that may be inaccessible to ground vehicles, and areas where there are species of concern.
  - Mechanically control weed populations when clearing large areas where weeds are widespread, and provide dense coverage, including the use of power tools and heavy machinery to remove noxious weed species. Clean mechanical equipment in designated facilities or equipment wash stations before treatment and before leaving the treatment area. Equipment wash stations may be temporary and will have a filter system, for example at least 6 inches of large cinder or gravel spread over a 10-foot by 30-foot area. Filter cloth may be used for temporary stations. The area will be a perched drainage to allow excess moisture to drain after being filtered. It must be at least 300 feet from a natural drainage to avoid contamination. Use a wash system or water trucks with potable water for equipment cleaning. Inspect the equipment wash area and staging area for weed seed and plant material and properly dispose of such material by bagging and incinerating it.
  - Use chemical control of weed populations, including the use of herbicides to control exotic plant species. The method that is chosen for a project site may depend on the size of the infestation, the species present, accessibility to the site, topography, resources and equipment

available, and finances. Use herbicides according to their labels and ensure a certified pesticide applicator is on-site. Provide water for mixing the herbicide and cleaning herbicide equipment, either by transporting potable water onto the site or by using local water sources after obtaining a water use permit. For remote sites, obtain a water use permit in compliance with the local water code. An anti-siphon and backflow preventer device is required to prevent contamination of the water source.

- Use existing infrastructure to reduce impacts. For example, to the extent possible, locate new ROWs in or parallel to existing roads or existing corridors to minimize resource impacts.
- Place new infrastructure, such as transmission lines and pipelines, in roads or follow existing infrastructure and disturbances, where feasible, to minimize new disturbances and habitat fragmentation.
- Limit new oil and gas development in badlands or lands with similar characteristics.
- Limit placing new infrastructure, such as transmission lines and pipelines, in Federal Emergency Management Agency 100-year floodplain roads by crossing designated corridors or collocating them and paralleling approved linear authorizations. This is to minimize disturbance and conserve undisturbed areas and water resources.

Appendix C
Conditions of Approval

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ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS	Full Phrase
APD	application for permit to drill
BLM	United States, Department of the Interior, Bureau of Land Management
CCNHP	Chaco Cultural National Historical Park
CFR	Code of Federal Regulations
COA	condition of approval
FFO	Farmington Field Office
ft	feet
km	kilometer
LFN	low frequency noise
LIDAR	light detection and ranging
m	meter
mi	mile
NMDOT	New Mexico Department of Transportation
NO_x	nitrogen oxide
NSA	noise sensitive area
NTL	notice to lessee
ROW	right-of-way
TCP	traditional cultural property
VOC	volatile organic compound

Appendix C. Conditions of Approval

COAs are conditions or provisions (requirements) under which APD is approved, after a lease is issued. COAs are based on site-specific analysis and are designed to minimize, mitigate, or prevent impacts on resource values or other uses of public lands. The application of a particular COA is not an RMP-level decision. Not all COAs in this appendix will be required for every oil and gas operation, and additional COAs beyond this list may be required, based on site-specific analysis. The surface owner (including the Navajo Nation and Navajo individual Indian allottees) will determine the application of COAs to projects on federal minerals beneath non-BLM surface lands.

C.1 BLM AND BIA

C.1.1 General Fluid Mineral COAs

- NM-10 drainage stipulation for federal minerals put up for lease: All or part of the lands contained in this lease is subject to drainage by wells(s) located adjacent to this lease. The lessee/operating rights owner is required within 60 days of lease issuance to submit to the BLM Authorized Officer plans for protecting the lease from drainage. The BLM will assess compensatory royalty after the expiration of this 60-day period if no plan is submitted. The plan must include either an APD, for a protective well, or an application to communitize the lease so that it is allocated production from a protective well off the lease. Either of these options may include obtaining a variance to State spacing for the area.

  In lieu of this plan, the lessee is required to demonstrate that a protective well would have little or no chance of encountering oil and gas in quantities sufficient to pay in excess of the costs of drilling, completing, and operating the well.

  In the absence of either an acceptable plan for protecting the lease from drainage or a thoroughly documented justification why a protective well would be uneconomical, the lessee is obligated to pay compensatory royalty to the Office of Natural Resources Revenue at a rate to be determined by the BLM Authorized Officer.
- OG-MA-26: All COAs will be consistent with valid existing rights.
- Operators are required to keep their locations free of trash and debris. They may be required to provide the BLM with a remediation and prevention plan, if their locations continue to have trash issues.
- Require H_2S signage using a clearly discernable symbol.
- Require gating and posting signs closing off roads, as necessary.
- Require use of sensors that alert when a valve is left open.
- Require posting a phone number for reporting issues at each well site.
- Require additional spill control measures in environmentally sensitive areas.
- Require use of heated valves and remote sensors that allow instantaneous shut off in case of spills.
- <u>Well pads and rights-of- way would avoid range plots and improvements to not cause degradation to the plot or improvement that would take away from the intent of the improvement.</u>
- There would be a maximum of 30 days between well pad construction and well spud.

C.1.2 Air Quality

- AQ-MA-3: Unless ongoing monitoring and additional modeling indicate otherwise, the following mitigation measures are required:
  - Emissions Control (construction)—Construction will be limited to only four wells concurrently in any given square mile, with each well no closer than half a mile of each other.

   - Emissions Controls—Implement measures if they are developed through the NMED's Ozone Attainment Initiative. The Ozone Attainment Initiative is a project authorized by State Statute, 74-2-5.3 NMSA 1978 (see http://public.nmcompcomm.us/nmpublic/gateway.dll/?f=templates&fn=default.htm). This statute directs the NEMED to develop plans, which may include regulations more stringent than federal rules, for areas of the state in which ambient monitoring shows ozone levels at or above 95 percent of the 2015 NAAQS of 70 ppb. Currently, both San Juan and Rio Arriba Counties are within 95 percent of the 2015 ozone standard. NMED is in the initial stages of analysis and planning for public outreach; however, 2014 National Emissions Inventory data suggest that, for these two counties, oil and gas production facilities will be a primary focus. The overall goal is to keep all areas now meeting the standard in attainment of the standard. Currently, the initiative is not part of the State Implementation Plan (SIP), although the plans, regulations, and authorizing statute may eventually become part of the SIP.
   - Participation on the Four Corners Air Quality Group—The BLM and BIA will participate in the Four Corners Air Quality Group. It will do this to continue its support of EPA's Ozone/PM Advance Program. As the Air Quality Group makes specific recommendations, the BLM will incorporate them, within its legal authority, as mitigation measures under 43 CFR 3162.1.
- The following measures may be required:
   - Improved engine technology for diesel rigs and mobile and non-road diesel engines (the best available from engine manufacturers)
   - Silicon-controlled-rectifier or nonselective catalytic reduction for drill rig engines and compressors
   - Natural gas-fired drill rig engines, where on-site processing of field gas is available
   - Electrification of drill rig engines or wellhead compressors, where power is available
   - Reduced emissions completions for oil wells, when technically feasible (adequate pressure and flow, tanks and dehydrators on-site, or the availability of a sales line; note that reduced emissions completions are required under federal regulations for all gas wells)
   - Flaring of oil well completion emissions (no venting)
   - Minimize/eliminate venting during blow downs, if technically feasible
   - Eliminate evaporation pits for drilling fluids
   - Capture and control flash emissions and other emissions (95 percent VOC control) from storage tanks
   - Centralized gas processing, liquid gathering systems, pipelines, water, or fracturing liquids delivery
   - Low-bleed/no-bleed pneumatics required for new wells
   - Dehydrator emission controls (95 percent control for VOC and methane)
   - Solar telemetry and well automation
   - Installation of plunger lift system where adequate pressure exists
   - Installation of low VOC emitting seals, valves, hatches
   - Periodic leak detection and repair program (use of forward-looking infrared cameras, sampling, inspection, vapor detection)
   - Require vapor recovery on truck loading/unloading operations
   - Treat unpaved roads to reduce fugitive dust from vehicle traffic, applying water and base coarse materials
   - Limit vehicle speeds on unpaved roads
   - Reduce commuter vehicle trips by establishing work camps and using car pools and commuter vans
   - Reduce vehicle idling
   - Reduce pace of development

C.1.3 Noise

- Application of noise standards in NSAs
  - All or a portion of approximately 62 SDAs established through the BLM land use planning process are being identified as NSAs.
  - Noise will be measured on the A-scale, using the attached protocol. The sound level (A-scale) must be less than or equal to 48.6 dBA over a continuous 24-hour period (i.e., 48.6 dBA Leq). This requirement applies to oil and gas lease operations that operate on a continual (over 8 hours/day), long-term (over a 1 week in duration) basis. The NTL will not apply to transient operations, such as construction, drilling, completion, or workover activities, or to temporary non-oil and gas sound sources. These activities will be handled on a case-by-case basis should a conflict be identified during the permitting process. The NTL does not apply to short-term activities, such as well venting and compressor start-ups.
  - Noise control will be receptor- or boundary-focused, as determined by agency management guidelines established for the designated Special Management Areas, areas of critical environmental concern, or other designations. Receptor-focused control will apply to 46 BLM and 4 Forest Service NSAs. Receptor-focused areas may be campgrounds, picnic areas, and shorelines. Boundary-focused control will include all designated acreage within seven BLM NSAs (refer to the tables table listed below), three Forest Service NSAs, and one NPS NSA, in addition to all Bureau of Reclamation land around Navajo Reservoir.
  - Receptor-focused NSAs—Noise standards of 48.6 dBA Leq will be achieved at established agency receptor points in the NSAs. Established receptors are generally defined as visitor use areas, camps or picnic areas, habitat for threatened or endangered species, archaeological sites, and recreation trails. Receptors may vary in size, from a single point source to several acres, based on the features and resource components that are being managed for sound. The agency will work with the operator to establish the applicable receptor points. Zones of 0 to 100 feet from the defined receptor may be established. The SDAs in which receptors will be designated are as follows (areas where stricter standards may apply are designated by ***):

BLM Receptor-Focused NSAs

***Andrews Ranch
***Bee Burrow
***Bis sa'ani
Bi Yaazh
Blanco Star Panel
Cagle's Site
***Casamero Community
Christmas Tree Ruin
Church Rock Outlier
***Crow Canyon
Delgadito-Pueblo Canyons
Dogie Canyon Schools
Encinada Mesa-Carrizo Canyon (Gomez Point, Gomez Canyon, Hill Road Ruin)
Frances Canyon (Frances Ruin)
Gonzalez Canyon-Senon S. Vigil Homestead
Halfway House
Haynes Trading Post
Holmes Group
***Indian Creek
***Jacques
***Kin Nizhoni
Margarita Martinez Homestead
Martin Apodaca Homestead
***Morris 41
Moss Trail
North Road (Segments 1, 2, ***6, 7)
***Pierre's Site
Rockhouse-Nestor Martin Homestead
San Rafael Canyon
Simon Ruin
Superior Mesa
Tapacito and Split Rock
***Toh-la-kai
***Twin Angels
***Upper Kin Klizhen
Allen Run
***Angel Peak
Glade Run
***Navajo Lake Horse Trail
Negro Canyon
Pinon Mesa
***Simon Canyon
***Bald Eagle
Reese Canyon
River Tracts
Mexican Spotted Owl

USFS Receptor-Focused NSAs

***Buzzard Park Campground
***Cedar Springs Campground
***Gasbuggy
Carracas Mesa Administrative Site

- Boundary-focused NSAs—For noise sources inside NSAs, the standard is 48.6 dBA Leq at 400 feet in all directions from the noise source. For noise sources outside designated NSAs, the standard of 48.6 dBA Leq must be met at the boundaries of the NSAs. Noise sources within 400 feet of the NSA boundary will generally be allowed to meet the standard 400 feet from the source. The SDAs that will be boundary-focused NSAs are as follows (areas where stricter standards may apply are designated by ***):

BLM Boundary-Focused NSAs

***Cho'Il'I (Gobernador Knob)
Dzil'na'oodlil (Huerfano Mesa)
Fossil Forest RNA
Carracas Mesa
Thomas Canyon ERMA/Wildlife Area (original acreage)
***Ah-shi-sle-pah WSA
***Bisti/De-Na-Zin Wilderness

USFS Boundary-Focused NSAs

Middle Mesa Raptor Area (prior approval required)
Ulibarri Raptor Area (prior approval required)
Munoz Canyon Raptor Area (prior approval required)

NPS Boundary-Focused NSA

***Aztec Ruins National Monument

Bureau of Reclamation Boundary-Focused NSA

All Bureau of Reclamation land around Navajo Reservoir

- Occupied dwellings, residences, and buildings—For noise sources involving federal or Indian leases near occupied dwellings or buildings, the standard of 48.6 dBA Leq will be met 100 feet from any such structure. This policy will not apply to unoccupied lands but can be enforced when those lands are developed. When oil and gas operations pre-date occupancy, the new resident will be asked to contribute to noise mitigation. For noise sources in incorporated city or township limits, the standards of that municipal jurisdiction will normally be applied; however, if there is no municipal standard, the BLM will enforce this NTL for noise sources associated with federal minerals.
- Stricter standards—Stricter standards may be applied to NSAs identified by a triple asterisk in the tables above. In these instances, the BLM may need the flexibility to adjust the general noise standard. The BLM, Forest Service, BOR, and NPS staffs will work with the operator on a case-by-case basis to achieve an acceptable level of noise mitigation. Factors considered in this process would be (1) the particular aspects of the area, such as landscape and topography, (2) resource values and uses, (3) public values and uses, and (4) the extent to which the 48.6 dBA Leq impairs values and uses.
- New NSAs—In addition to the 62 areas listed in the tables, new Special Management Areas, camping, picnic, or trail areas may be identified or developed by land management agencies. This policy would be implemented in or near these areas after a 30-day notice to the affected parties, using Section VI schedules.

- OG-MA-27—Noise from oil and gas equipment that operates more than 8 hours/day for more than 1 week will be kept at or below 48.6 dBA Leq at specific locations. This is to minimize disturbances to people and to nest sites for golden eagles, ferruginous hawks, and prairie falcons.
- Average noise levels at sensitive receptors, including the CCNHP, World Heritage Sites, areas of critical environmental concern, and other identified historic properties where setting and feeling are key to their eligibility to the NRHP, must be no higher than 48.6 dBA Leq (current noise policy). As noted in **Chapter 3**, to the NRHP, historic properties are defined as districts, site, buildings, structures, and objects significant in American history, archaeology, engineering, and culture.
- Noise levels at residences, schools, churches, CIMPPs, the boundary of CCNHP, and Chacoan outlier cultural sites must be no higher than 48.6 dBA Leq.
- Require mufflers, minimize vehicle traffic, install directional baffles to reduce noise levels at roads, outliers, other Chacoan sites, Navajo sites with high visitation, public historic sites, sites used for ceremonies, pilgrimages, and offerings, and Dinetah defensive sites. Apply seasonal timing limitations on traffic levels, drilling, and other noisy activities, based on the timing of important local and Tribal activities and peak seasons for visitors at CCNHP.

  Minimize noise using the best available technology, such as installing multi-cylinder pumps, hospital-grade sound-reducing mufflers, and exhaust systems to direct noise away from sensitive receptors, such as residences, CCNHP, established campgrounds, and sensitive wildlife habitat. The goal for the minimum level of acceptable change would be a 10 dbA or less increase from ambient background levels; however, at no time should operations exceed the 48.6 dBA outlined in the FFO Noise NTL.
- In addition to noise levels measured on the dBA Leq scale, as outlined in the Management of Sound Generated by Oil and Gas Production and Transportation (NTL 04-2 FFO), oil and gas drilling and production activities may be measured on the dBC Leq scale. This is to identify the impact of low frequency noise (LFN) on the environment, especially when operations occur within 0.25 mile of occupied buildings.
- A sound level measurement on noise emitted from oil and gas drilling, completion, or production operations that will be measured on the dBC Leq scale will be taken at 25 feet from the exterior of the occupied building nearest to the noise source. If the sound level measurement exceeds the dBC Leq thresholds, the BLM may require the operator to submit an LFN impact analysis and to identify reasonable control measures to mitigate any impacts.
  - For daytime operations or when LFN sources operate intermittently (1 to 2 hours), the sound level measurement thresholds are as follows:
  - Desirable—Leq 60 dBC
  - Maximum—Leq 70 dBC
  - For nighttime operations or when LFN sources operate continuously (24/7) the sound level measurement thresholds are as follow:
  - Desirable—Leq 60 dBC
  - Maximum—Leq 65 dBC
- Sound level measurements should follow the procedure outlined in NTL 04-2 FFO

C.1.4 Cultural Resources

- The following mitigation measures apply to situations that may occur during surface-disturbing activities. Others may be developed to apply to site-specific activities and permits, as appropriate to the location:
  - Discovery of cultural resources in the absence of monitoring—If, during operation, an operator/holder discovers any previously unidentified historic or prehistoric cultural resources, then work in the vicinity of the discovery will be suspended and the discovery will be

immediately reported to the BLM Field Office Manager. The BLM will then specify what action to take. If there is an approved discovery plan in place for the project, then the plan will be executed. In the absence of an approved plan, the BLM will evaluate the significance of the discovery and will consult with the SHPO and THPO(s) (as appropriate), in accordance with 36 CFR 800.11 and 36 CFR 800.13.

- Discovery of cultural resources during monitoring—If monitoring confirms the presence of previously unidentified cultural resources, then work in the vicinity of the discovery will be suspended and the discovery will be immediately reported to the BLM Field Office Manager. The BLM will then specify what action to take. If there is an approved discovery plan in place for the project, then the plan will be executed. In the absence of an approved plan, the BLM will evaluate the significance of the discovery and will consult with the SHPO and THPO(s) (as appropriate), in accordance with 36 CFR 800.11.
- Damage to sites—If, during operations, an operator or lease holder damages, or is found to have damaged, any previously documented or undocumented historic or prehistoric cultural resources (excluding discoveries, as noted above), the operator or lease holder agrees, at its expense, to have a permitted cultural resources consultant prepare and have executed a BLM-approved data recovery plan. Damage to cultural resources may result in civil or criminal penalties, in accordance with the Archaeological Resource Protection Act of 1979, as amended.

- Require operators to collocate authorized roads, pipelines, electrical lines, and other activities within 1 mile of historic properties eligible to the NRHP under Criteria A, B, or C (or those with the potential for similar eligibility pending further information) and prominent landforms. Examples are twinning existing well pads and ensuring that pipelines follow access roads or using existing pipeline and power line corridors. This requirement applies to existing and new disturbances. Exceptions will be made when the following criteria are met: To route around archaeological sites or mitigation of indirect impacts on historic properties eligible to the NRHP under Criteria A, B, or C (or those with the potential for similar eligibility pending further information).

  Waiver, exception, and modification—If circumstances or relative resource values change, or if it can be demonstrated that oil and gas operations can be conducted without causing unacceptable impact, then the BLM Authorized Officer may waive, make an exception for, or modify them. This would be allowed if such action is consistent with the provisions of the Farmington RMP or, if not consistent, through a land use plan amendment and associated National Environmental Policy Act analysis document. If the BLM Authorized Officer determines that the waiver, exception, or modification involves an issue of major public concern, the waiver, exception, or modification would be subject to a 30-day public review period.
- No staging areas visible from the CR7900 or CR7950 into CCNHP (applies to oil and gas ROWs only).
- Before development begins, operators will be required to conduct light detection and ranging (LIDAR) surveys on new leases, if there are no previous LIDAR surveys of the area to QL2 standard. Operators also must conduct an ethnographic study on new leases, if one has not been conducted, and must install seismic monitoring equipment for CCNHP or historic properties with standing architecture.
- Oil and gas ROWs—Notifying Navajo Nation chapter houses and other Tribes with cultural affiliation is required if any major roads are under construction, so Tribal members can access CIMPPs.
- Required mitigation measures may include, but are not limited to, the following:
  - Contribute funding for an intensive inventory for Chacoan road crossings
  - Stabilize the site
  - Fund educational pamphlets and interpretive signs about cultural resources

- Fund monitoring and management of cultural sites (including law enforcement)
- Fund the collection of LIDAR data
- Fund ethnographic research (potentially 1 percent of project budget)
- Fund restoration of the setting surrounding affected cultural sites
- Fund development of historic contexts for various important cultural periods or events
- Install seismic monitoring equipment for CCNHP or historic properties with standing architecture

- Require blending surface facilities into the existing landscape. Use the same polygons for anything that is leased—viewshed of foreground roads, outliers, other Chacoan sites, Navajo sites with high visitation, public historic sites, Dinetah defensive sites, CIMPPs, and prominent landforms—using the following:
  - Vegetation screening
  - Landscape-appropriate paint color from the BLM color palette
  - Low-profile tanks, as appropriate (liners, if tanks are buried)
  - Organic rather than angular shapes for facilities
  - Edge feathering
  - Curvilinear road alignments
  - Well pad and road surfacing blended with landscape
  - Off-site facilities, liquids gathering systems
  - Subsurface pumpjacks, when economically and technically feasible
  - Flaring shields/covers
  - Required design features to minimize or eliminate the visual intrusions on the cultural landscape; design features must be used as site-specific conditions warrant and must be part of the ROW applicant's project siting/design, prior to application.
- Noise from oil and gas equipment that operates continuously[1] will be kept at or below 48.6 dBA Leq at specified locations. This is to minimize disturbances to people, as well as to nest sites for golden eagles, ferruginous hawks, and prairie falcons and at sensitive receptors in the CCNHP and roads and outliers.
- Average noise levels at sensitive cultural receptors must be no higher than 48.6 dBA Leq.
- Require mufflers, minimize vehicle traffic, and install directional baffles to reduce noise levels at roads, outliers, CIMPPs, prominent landforms, other Chacoan sites, Navajo sites with high visitation, public historic sites, and Dinetah defensive sites. Apply seasonal timing limitations on traffic levels, drilling, and other noisy activities, based on the timing of important local and Tribal activities. Noise levels at sensitive receptors, including residences, churches, CIMPPs, and the boundary of CCNHP, cannot exceed 48.6 dBA Leq.
- Require programs to educate workers on the importance of protecting archaeological and ethnographic cultural resources.
- Do not allow construction, drilling, well completions, geophysical activities, or workover rigs in identified traditional use areas during traditional ceremonies, offerings, or pilgrimages, with the exception of emergencies/exemption criteria. The BLM must receive proper notification of ceremonies, offerings, or pilgrimages to which this condition would apply.

C.1.5 Dark Skies

- A lighting plan to protect dark skies will be developed before development begins. The lighting plan will address the construction, drilling, completion, and production stages and will specify the following:

[1] More than 8 hours/day on a long-term basis, which is more than 1 week in duration.

  - Number of lights and lumen output of each—Minimum number of lights and the lowest luminosity consistent with safe and secure operation of the facility
  - Alternatives to lighting—Retro-reflective or luminescent markers in lieu of permanent lighting, where feasible
  - Fixture design—Lights of the proper design (full cutoff luminaires if possible), fully shielded to eliminate uplight, and restricting illumination between 80° and 90° from nadir, and directed to eliminate light spill and trespass to off-site locations
  - Lamp color temperature—Lights of the proper color to minimize night-sky impacts (less than 3,000° Kelvin)
  - Standard operating procedures—Minimization of unnecessary lighting through alternatives to permanent lighting, such as using timers, motion sensors, or switches to restrict lighting use to certain times and to provide lighting only when it is needed
  - Any activities that may be restricted to avoid night-sky impacts
  - A process for immediately addressing and mitigating complaints about potential light impacts
- A flaring plan to protect dark skies will be developed before development begins. The flaring plan will specify the following:
  - Mitigation measures to reduce the duration of night-time flaring
  - Mitigation measures to reduce light trespass from flaring, such as the following:
  - Enclosed combustors
  - Temporary blinds or shields to prevent light trespass toward sensitive key observation points, including residences, CCNHP, Bisti/De-Na-Zin Wilderness, and other important dark sky viewing places
  - Flare heights at the minimum distance for safety, while reducing the light trespass-affected area
- A light trespass viewshed analysis will be conducted before development begins to determine the area of potential effect from artificial lights and flaring during the construction, drilling, completion, and production stages. The viewshed analysis will incorporate the height, direction, and luminosity of these artificial light sources. Based on this viewshed analysis, light trespass from artificial lights and flaring in the lighting and flaring plan will be reduced.
- Enclosed combustors or other available technology that reduces flare light trespass will be used.

C.1.6 Paleontological Resources

- Restrict vehicles to existing roads and trails.
- A pedestrian survey must be conducted for paleontological material, using a qualified permitted paleontologist determined by the BLM, as part of the permit application for the proposed lease activity in geologic units that are classified on the BLM's PFYC scale as a PFYC U—unknown, 4, or 5, as determined by the BLM Authorized Officer. The survey and report would be used to determine the presence of paleontological material exposed at the surface and, if necessary, the appropriate mitigation of ground-disturbing activities, such as monitoring, avoidance, and/or project redesign.
- The lessee shall immediately notify the BLM Authorized Officer of any paleontological resources discovered as a result of approved surface-disturbing operations. The lessee shall suspend all activities in the vicinity of such discovery until notified to proceed by the BLM Authorized Officer and shall protect the discovery from damage or looting. The BLM Authorized Officer would evaluate, or would have evaluated, such discoveries after being notified and would determine, after consultation with the operator and the BLM Regional Paleontologist, the appropriate measures to mitigate adverse effects on significant paleontological resources. Upon approval of the BLM Authorized Officer, the operator would be allowed to continue construction through the site, or would be given the choice of either:

- Following the BLM Authorized Officer's instructions for stabilizing the fossil resource in place and avoiding further disturbance to the fossil resource or
- Following the BLM Authorized Officer's instructions for mitigating impacts on the fossil resource prior to continuing construction through the project area. The lessee is responsible for any cost associated for mitigating paleontology resources discovered as a result of their activities.

- An avoidance zone around all recorded fossil localities may be applied, based on known extent of resources.
- When avoidance is not possible, appropriate mitigation may include excavation or collection (data recovery), stabilization, monitoring, protective barriers, and signs.
- Project or ground-disturbing activities may be relocated, based on the results of the paleontology field survey.
- All persons associated with operations under this authorization will be informed that any objects or sites of paleontological or scientific value will not be damaged, destroyed, removed, moved, or disturbed. Examples of such objects are vertebrate or scientifically important non-vertebrate fossils. Any paleontological resource discovered by the operator or by any person working on the operator's behalf will be immediately reported to the BLM Authorized officer. The operator will suspend all construction within 100 feet of said find. A BLM-permitted paleontologist will evaluate the paleontological resource within 5 working days, weather permitting, to determine the appropriate actions to prevent the potential loss of any significant paleontological resource. Operations within 100 feet of such a discovery will not resume until the BLM Authorized Officer issues written authorization to proceed, pending the collection or salvage of any fossils of scientific interest. Any unauthorized collection or disturbance of paleontological resources may result in a shutdown order by the BLM Authorized Officer. The operator will be held responsible for the cost of proper mitigation measures. The BLM Authorized Officer will consult with the operator on the evaluation and decisions of the discovery.
- On-site monitoring in areas with a high probability for buried fossils will require the presence of a monitor at all times during the disturbance. The monitor will assess any finds, collect loose fossil material and related data, and take appropriate steps to mitigate any damage. Activities should be assessed relative to the potential to uncover significant fossils. Construction may need to be suspended during the nighttime in sensitive areas, to allow surveys to adequately monitor activities.
- Require a treatment plan for any activities that will affect the scientific integrity of significant paleontological resources.
- Surface-disturbing activities will not be allowed on known paleontological sites.
- Surface-disturbing activities will be prohibited within 100 feet of recorded fossil locations.
- A case-by-case examination of any proposed surface-disturbing activities will be made to determine potential adverse effects. Appropriate mitigation will be applied to minimize those effects.
- Paleontological surveys will be required for surface-disturbing activities in the following areas:
  - Those with a high probability for buried fossils
  - Those with a potential for significant paleontological resources
  - Known paleontological sites
  - Recorded fossil locations
- A preconstruction field meeting will be conducted before any dirt work approved under APDs or ROWs begins in the following locations:
  - Those with a high probability for buried fossils
  - Those with a potential for significant paleontological resources
  - Known paleontological sites
  - Recorded fossil locations

- The operator will notify the BLM via email at least 48 hours before any surface-disturbing activities begin in the following areas:
  - Those with a high probability for buried fossils
  - Those with the potential for significant paleontological resources
  - Known paleontological sites
  - Recorded fossil locations
- To reduce disturbance and minimize habitat fragmentation, pipelines are required to follow existing disturbance, where feasible, which may include roads, utility ROWs and pipelines, and corridors.
- Restrict cross-country ROWs in badlands. Require land use authorization actions, such as transmission and pipelines, in roads or follow existing disturbance, when existing infrastructure allows.

C.1.7 Visual Resources

- Measures for visual resources listed below apply primarily to mineral extraction and are not all inclusive. Additional mitigation measures for mineral extraction or other program activities may be developed and implemented as necessary:
  - Operators may be required, on a case-by-case basis, to leave a tree screen on one or more sides of a location.
  - Aboveground structures are required to be painted in one of five colors designated to blend with the natural color of the landscape.
  - Permit holders are required to coordinate with the BLM Authorized Officer on the design and color of power poles and transmission lines, to achieve minimal practicable visual impacts.
  - Permit holders may be required to reconstruct rock rims as near as possible to their original condition.
- Construct and design surface facilities to blend with the surrounding landscape and topography.
  - Use appropriate vegetation treatments so that the vegetation community will return to the stated goals for vegetation management.
  - Activities that would be considered to meet this goal are the following:
  - Vegetation screening
  - Landscape-appropriate paint color from the BLM color palette
  - Low-profile tanks, as appropriate
  - Organic rather than angular shapes for facilities
  - Edge feathering
  - Well pad and road surfacing blended with the landscape
  - Off-site facilities
  - Low gravity solids
  - Partially buried tanks
  - Curvilinear design in road planning

C.1.8 Soil Resources

- SR-MA-3—Various techniques will be used to reduce soil erosion. Most measures focus on reducing the amount of surface disturbance, protecting disturbed soils from water or wind erosion, and restoring natural vegetation as soon as possible. Depending on the site-specific situation, the chief mitigation measures to be used are the following:
  - Operators are required to submit a plan of reclamation to the BLM.
  - Clearing, grading, and other disturbance of soil and vegetation is limited to the minimum area required for construction.

  - Any roads used exclusively for construction will be adequately closed to all vehicles and will be rehabilitated after construction.
  - Topsoil removed during construction will be stockpiled and used in reclamation.
  - Side hill cuts of more than 3 feet vertical are not permitted. Areas requiring cuts greater than 3 feet will be terraced.
  - Disturbed areas will be mulched, as designated by the BLM Authorized Officer.
  - Disturbed areas will be reseeded, using designated seed mixtures, within 1 year of final construction.
  - No construction or routine maintenance will be performed when the soil is too wet to adequately support construction equipment. If such equipment creates ruts in excess of 6 inches deep, the soil will be deemed too wet to work.
  - All roads will follow Gold Book standards
- Operators are required to submit a reclamation plan.
- Operators will maintain inspection forms that the BLM Authorized Officer can request to see at any time.
- Production facilities will be placed to allow for maximum interim reclamation and revegetation of the well location.
- All sections of the proposed access road associated with this permit will be sited, designed, constructed, upgraded, and maintained using standards, requirements, guidelines, and instructions specified in BLM Manual 9113, Roads Design Handbook; BLM Manual 9113-2, Roads National Inventory and Condition Assessment Guidance & Instructions Handbook; and Surface Operations and Guidelines for Oil and Gas Exploration and Development, the Gold Book.

  For any construction, operators will notify the grazing lease operators at least 10 business days before construction begins. This is to ensure that there will be no conflicts between construction and livestock grazing. The operator is in no way obligated to cease or delay construction, unless directed by the BLM Authorized Officer. Any range improvements, such as fences, pipelines, and ponds, disturbed by construction will be repaired immediately following construction to the condition they were in before the disturbance.
- No surface disturbance will be allowed on slopes greater than 20 percent in the Reese Canyon Research Natural Area or Carracas Mesa Special Management Area.
- Surface disturbance or development on slopes greater than 20 percent could be prohibited, unless individual site plans meet certain requirements. An example of these requirements is providing engineered drawings for construction that include site drainage and final rehabilitation contours. A written rationale should accompany the plan, describing how the proposed controls would prevent slope failure and erosion, while maintaining viable topsoil for final reclamation. Site plans could be required to include a timeline, identifying the actions that would be applied during construction, production, and rehabilitation. This is so the BLM can develop appropriate monitoring protocols to ensure that the plan is meeting the objectives.

  Additionally, facility locations could be prohibited within 656 feet (200 meters) of ephemeral and perennial drainages and wetlands and riparian areas. Roads and pipelines crossing drainages could be required to have mitigations that would minimize surface disturbance and reduce or eliminate erosion.

  After development, operators are required to stabilize fragile soils.

C.1.9 Water Resources

- The following mitigation measures will be applied, as appropriate, to protect surface water and groundwater from the impacts of surface disturbance:
  - Drilling pits will be lined with an impervious material at least 12 mils thick.

- Mud and blow pits will be constructed so as not to leak, break, or discharge liquids or produced solids.
- Washes will be diverted around well pads.
- Culverts of a minimum of 18 inches will be placed where drainages cross access roads.
- Low water crossings will be constructed to prevent any blockage or restriction of the existing channel. Material removed will be stockpiled for use in rehabilitating the crossing.
- Full compliance with all applicable laws, regulations, and onshore orders is required.
- Before a well location is approved within 500 horizontal feet of the high-water line of the Navajo Reservoir (elevation 6,085 feet), the BOR must examine it to determine the potential impacts on water quality.

- Water used to construct, produce, and maintain actions authorized by this permit to drill or water authorized for use by the New Mexico Oil Conservation Division must be acquired from permitted water sources. On request, the operator will provide the BLM Authorized Officer with documentation of water sources.
- Hydraulic fracturing operations will follow best practices, as follows:
  - The public disclosure on the FracFocus.org website of chemicals used in hydraulic fracturing on federal and Indian lands
  - Confirmation that wells used in fracturing meet appropriate construction standards
  - Appropriate plans for managing flowback waters from fracturing
- Operators are required to disclose where they get water from and to identify state-approved water sources.

C.1.10 Riparian Areas and Wetlands

- In the 100-year floodplain, well pads and facilities are to be built up to protect equipment and infrastructure from flooding.
- Development in the 100-year floodplain will be avoided and will be moved out of the 100-year floodplain, if necessary.

C.1.11 Vegetation

- Water features that may pose a future threat to the project will be armored and will include outside areas.
- Site-specific mitigation measures will be developed to mitigate the removal or disturbance of riparian and wetland vegetation. Site integrity must be maintained to avoid negative impacts on riparian and wetland area that may be associated with the natural lateral movement of the active channel.
- Revegetation would be considered satisfactory when soil erosion resulting from the operation has been stabilized, and a vegetation cover equal to 70 percent (both cover and diversity of species) of preexisting or seeded-in vegetation is reestablished, as evidenced by pre-and post-construction photo-point monitoring and vegetation plots and transects.
- Reseeding would be required if satisfactory interim reclamation progress is not being made at year 2 or year 3 monitoring intervals, or if final reclamation is not achieved by year 5.

C.1.12 Noxious and Invasive Weeds

- All seed, hay, straw, mulch, or other vegetation material transported and used on public land for site stability, rehabilitation, or project facilitation will be certified noxious weed free.
- If fill dirt or gravel is brought onto public lands, the source needs to be noxious weed free.
- All surface-disturbing equipment would be inspected and cleaned before being brought onto public lands.

- If bare ground vegetation treatment (trim-out) is desired around facility structures, operators will submit a bare ground/trim-out design with their surface use plan of operations. The design will address vegetation safety concerns of the operators and the BLM, while minimizing impacts on interim reclamation efforts. The design must include the structures to be treated and zone distances of trim-out. Herbicides for vegetation control around anchor structures would not be approved. If herbicides are used for bare ground trim-out, the trim-out will not exceed 3 feet from the edge of any eligible permanent structure, such as well heads, fences, and tanks. Vegetation in a berm area (i.e., secondary containment of tanks) may be treated to the bare ground, except in areas greater than 3 feet around the berm perimeter. Additional distances and areas may be requested and must be approved by the FFO Authorized Officer.

C.1.13 Fish and Wildlife

- Use of pesticides and herbicides will comply with applicable federal and state laws.
- The permit holder will be responsible for weed control and selective control of invasive weeds on disturbed land and reclaimed areas, within the limits of the well pad, associated road, and pipeline ROW.
- The permit holder is responsible for consulting with the BLM Authorized Officer or local authorities, or both, for acceptable weed control methods, within the limits imposed in the COAs.
- Permanent or temporary pipelines for water disposal will be installed as early as possible to eliminate excessive truck traffic in sensitive wildlife areas. Exceptions may be considered on a case-by-case basis.
- Unguarded pits containing liquids will be fenced with woven wire. All fencing must be in accordance with New Mexico law.
- Unless otherwise agreed to in writing by the BLM Authorized Officer, power lines will be constructed in accordance with standards outlined in the Avian Protection Plan Guidelines (2005) or current best available data.
- In key areas, where practical, well data may be required to be transmitted electronically to reduce vehicle traffic and wildlife disturbance.

C.1.14 Special Status Species

- When individual plants or suitable habitat for these plants, as determined by the BLM, are found during a biological survey for a proposed well pad, pipeline, or other ground-disturbing project, the company proposing the project will be given the following options:
  - Relocate the project to miss the plants or habitat and drill conventionally
  - Relocate the pad and directionally drill (including horizontal drilling) to the target area
  - Transplant Clover's cactus and stockpile and respread soil, when appropriate, as determined by the BLM (every effort to relocate the proposed pad must be explored before the BLM will approve this)
- At least one pollinator-friendly native plant species will be used in all vegetation management projects or reclamation activities involving the use of seedings or seedlings. The goal will be to provide a suite of early blooming to late blooming flowering plants, to ensure that floral resources are available for pollinators throughout the growing season.
- Biological surveys for golden and bald eagles may be required for any proposed project within 0.5 miles of nesting habitat.
- Restrict activities within 0.25-0.33 mile of any active or inactive nest for raptors, including peregrine and prairie falcons, ferruginous hawk, and ospreys.
- Determine mitigation for peregrine falcon nest sites on a site-specific basis, using the principle of designating sensitive zones in which disturbance is seasonally restricted (Johnson 1994).

- In nesting bird habitat, follow existing infrastructure, when feasible, to ensure compliance with the Migratory Bird Treaty Act.
- For all special status plants—Blooming season surveys would be required. No transplanting would be allowed outside of the growing season or optimal time for transplanting, as determined by a consulted horticulturalist.
- Possible mitigation strategies for special status plants are the following:
  - Adjust the location of the disturbance outside of suitable habitat with disturbance buffer to eliminate to reduce impacts to special status plants
  - Use dust abatement
  - Use signs, fencing, and other deterrents to reduce possible human disturbance
  - Require construction to occur outside of the blooming season (September through March)
  - Use a higher percentage of forbs in the reclamation seed mix to promote pollinator habitat
  - When reclaiming the site, replace the soil and subsoil layers to the predisturbance order of soil horizons
  - Use a qualified, independent, third-party contractor to provide general oversight
  - Monitor and control nonnative and invasive species
  - Control 80 percent of fugitive dust within 330 feet (100 meters) of the edge of occupied, suitable, or potential special status plant species habitat (federally listed, proposed, and candidate species), using BLM-approved dust suppression methods, to be determined on a case-by-case basis
  - Require operators to collocate authorized roads, pipelines, electrical lines, and other structures within 330 feet (100 meters) of special status plant species habitat
  - Restrict development within 100 meters of occupied habitat
    - Adjust the location of the disturbance to be at least 100 meters from the edge of occupied or suitable habitat and ideally outside of the plant consideration area;
    - Minimizing the area of disturbance;
    - The use of dust abatement measures;
    - Using signs, fencing, and other deterrents to reduce possible human disturbance;
    - Requiring construction to occur outside of the blooming season (i.e., construction could occur November through March), involving possibly delaying the project by more than 60 days;
    - Requiring specialized reclamation procedures (e.g., separating soil and subsoil layers with barriers to reclaim in the correct order and additional emphasis on forbs in seed mixes to promote pollinator habitat);
    - Long term monitoring of the species and/or habitat;
    - Using a qualified, independent third-party contractor to provide general oversight and assure compliance with project terms and conditions; and/or
    - Nonnative or invasive species monitoring and control. These measures may also be applied to projects near suitable habitat that may hold special value or to provide protection to suitable habitat that may allow for species' expansion;
    - Collect seeds or other genetic material (according to Center for Plant Conservation protocols) to preserve any impacted populations. Material can be placed in long-term storage or seed can be used for restoration projects.

C.1.15 Communities

- No staging within 1 mile of homes, churches, schools, or clinics.

C.1.16 Livestock Grazing

- For any construction, the lessee will notify the grazing lease operator at least 10 business days before construction begins. This is to ensure that there will be no conflicts between construction and livestock grazing. The holder is in no way obligated to cease or delay construction, unless directed by the BLM Authorized Officer. In consultation with the grazing permittee and the BLM, range improvements disturbed by construction, including fences, pipelines, troughs, storages, and ponds, will be returned to a functional state as soon as possible and will be left in as good a condition or better than they were before the disturbance.

C.1.17 Travel and Transportation Management

- NM-4 Stipulation for Leases Subject to a Highway Material Site ROW—The lessee/operator will conduct operations in conformity with the following requirements:
  - The NMDOT will have unrestricted rights of ingress and egress to the ROW.
  - The lessee/operator will not conflict with the right of the NMDOT to remove any road-building materials from the ROW.
  - NMDOT reserves the right to set up, operate, and maintain such facilities as are reasonable to expedite the removal, production, and use of the materials; the lessee will not interfere with NMDOT's use of the property for such purposes.
  - The lessee/operator will make no excavations and erect no structures on the ROW that might be adverse to the use and interest of the land by NMDOT.
- Traffic control planning, including flagging, carpooling, speed limits, signs, and access planning, will be required.
- No construction, drilling, or completion traffic on roads with relevant jurisdiction during school bus pick-up and drop-off times.
- Roads will be planned and designed to minimize impacts on the environment and to reduce habitat fragmentation.
- Curvilinear designs in road network planning will be required.
- Roads will be planned and designed to minimize impacts on the environment and reduce impacts on Tribal communities; any planning affecting Tribes will include consultation.
- Reduced traffic will be required from dusk until dawn to reduce collisions with nocturnal wildlife.
- Reduced traffic will be required during peak local travel hours to minimize impacts on local traffic, such as school buses.
- Operators must obey local, county, and Gold Book speed limit requirements.

C.1.18 National Trails

- NM-6 Continental Divide Trail—No occupancy or other surface disturbance will be allowed within 1,000 feet of the Continental Divide National Scenic Trail Treadway.
- Modification—This distance may be modified when specifically approved in writing by the BLM.

C.2 BIA Only

C.2.1 General Fluid Mineral COAs

- Before the BLM's decision on issuing an APD for any proposed wells and associated operations and infrastructure, the potential lessee will be responsible for conducting air dispersion modeling for all proposed wells within 1 mile of a home site lease or house, barn, or occupied dwelling (including those structures occupied intermittently or seasonally) on Navajo Tribal trust and individual Indian allotment lands. The BLM will determine the near-field air quality impacts based on air dispersion modeling that conforms to Environmental Protection Agency guidelines. Based on modeling results, the BLM may have mitigation requirements, with a potential for moving the proposed well and associated operations and infrastructure away from the occupied dwellings. A plan of development will be required.

- NEPA analysis associated with the APD must contain the disclosure of the near-field air impacts from the development of these leases. The BLM will ensure that the federal agency activities and actions comply with all applicable air quality laws, regulations, standards, and implementation plans, per the 1990 CAA Amendments Section 118. The BLM will promote efforts to prevent damage to the environment and promote human health and welfare. In addition, the following mitigation actions may be required: Monitoring for hazardous air pollutants, including H_2S, in sensitive receptor locations on a continuous basis.

C.2.2 Cultural Resources

- For APDs with Tribal trust or individual Indian allotment surface lands, the APD applicant would comply with the Navajo Nation's Cultural Resources Protection Act (NNCRPA), as well as the Jishchaa' Policy. A site-specific survey of the APE would be conducted before ground-disturbing activities identified under the APD. For APDs on individual Indian allotments, the BLM would work with the BIA and Navajo Nation THPO to consult with landowners to determine final disposition of cultural resources and human remains. The Navajo Nation THPO would be requested to recommend the appropriate avoidance or other mitigation strategy for any historic properties, CIMPPs, or burials in the APE, as well as any other cultural resources that Navajo Nation THPO specifically identifies, with final determination from the Regional Director of the BIA. Per Section 106 of the NHPA and other relevant regulations, the BLM would consult with the Navajo Nation THPO, Tribes, local communities and Navajo chapters regarding cultural resources.

C.2.3 Navajo Nation Endangered Species List (NESL) Species Accounts COAs

When habitat or individual species; excluding fish species or species not known to occur within the planning area, as determined by the BIA, are found during a biological survey for a proposed well pad, pipeline, or other ground-disturbing project, the company proposing the project will follow the NNDFW NESL survey guidelines and avoidance requirements:

Mammals

- Black-Footed Ferret (*Mustela nigripes*): No alteration of prairie dog towns year-round where ferrets occur, or where no recent surveys have been conducted. Negative survey results are valid indefinitely if coverage included the entire town or complex (i.e., all towns within 7 kilometers [km]), otherwise results are valid for 1 year. Certain exceptions exist for actions of limited disturbance (see guidelines).
- Pronghorn (*Antilocapra americana*): No disturbance within 1.6 km (1 mile) of known and potential lambing areas during May 1 to June 15; install wildlife-friendly fences within occupied habitat; avoid disturbances that cause habitat fragmentation of wintering, fawning, and seasonal-movement corridors; consultation with NNDFW necessary.
- Townsend's Big-eared Bat (*Corynorhinus townsendii*): No closure of occupied mines or caves (hibernacula, day, or maternity roosts) until consultation with NNDFW; feasibility of gating mine/cave opening should be considered; no activity within 60 meters (m) of occupied roost-site during April 15 to August 31.
- Banner-Tailed Kangaroo Rat (*Dipodomys spectabilis*): Recommended no activity (year-round) within 60 m of occupied habitat that could result in destruction of burrows/mounds and take of individuals.
- Kit Fox (*Vulpes macrotis*): No ground-disturbing activities, year-round, within 60 m of known den-site; no activity within 0.2 km (⅛ miles [mi]) of active den during December 1 to August 31.

Birds

- BIRDS: NON-ENDANGERED RAPTORS and MIGRATORY BIRDS: Non-Endangered Raptors: No disturbance within 0.15 km (490 feet [ft]) of active nest during incubation to fledging (as determined by direct field observation or qualified literature source specific for nesting dates in the Southwestern US). Migratory Birds: No disturbance within 50 m (165 ft) of active nest during incubation to fledging (as determined by direct field observation or qualified literature source specific for nesting dates in the Southwestern US).
- Golden Eagle (*Aquila chrysaetos*): Use "Golden and Bald Eagle Nest Protection Policy": for active nests during January 15 to July 15, no brief activity within 600 m (0.37 mi), no light activity within 800 m (0.50 mi), no heavy activity within 1 km (0.62 mi), and no loud activity within 1.2 km (0.75 mi); no infrequent-use permanent structures within 800 m (0.50 mi), and no daily-use permanent structures with 1 km of any nest, year-round
- Ferruginous Hawk (*Buteo regalis*): No disturbance within 0.8 km (0.5 mi) of occupied nest during March 1 to July 31 for Brief activity; 1.0 km (0.62 mi) for Light activity; 1.2 km (0.75 mi) for Heavy activity; and 1.6 km (1 mi) for Loud activity; No daily-use permanent structure any time of year within 1.6 km (1 mi), and no infrequent-use permanent structures within 1.0 km (0.62 mi), of nesting territory. Nests without eggs by May 1st of any year are considered 'inactive' for that breeding season. Activity may commence 30 days post-fledging provided accurate age determination of young. Ferruginous Hawks are especially prone to desert nests if disturbed during incubation. Consult "Ferruginous Hawk Management Guidelines for Nest Protection."
- Yellow-Billed Cuckoo (*Coccyzus americanus*): No activity within 0.2 km (0.12 mi) of active nest from June 1 to September; extreme disturbances (e.g. blasting) may require larger restriction zone; no alteration of suitable habitat year-round within 0.4 km of habitat patches used for breeding, or potential habitat until surveyed.
- Southwestern Willow Flycatcher (*Empidonax traillii extimus*): ≥5 surveys, one in each period of May 15-31 and June 1-21, and ≥3 surveys during June 22 to July 17, with ≥5 days between surveys. USFWS Federal permit required.
- Bald Eagle (*Haliaeetus leucocephalus*): For wintering eagles, no activity during October 15 to April 15 within 0.8 km (0.50 mi) of roost/perch sites or lakes/rivers used for foraging; no tree removal in known roosting habitat. For nesting eagles, use 'Golden and Bald Eagle Nest Protection Policy': for active nests from January 15 to July 15 no brief activity within 600 m (0.37 mi), no light activity within 800 m (0.50 mi), no heavy activity within 1 km, and no loud activity within 1.2 km; no infrequent-use structures within 800 m (0.50 mi), and no daily-use structures with 1 km (0.62 mi) of any nest, year-round.
- Burrowing Owl (*Athene cunicularia*): No activity within 0.4 km (0.25 mi) of active nest burrow from March 1 through August 15; no habitat alteration year-round within 0.2 km (656 feet) of nest site.
- American Dipper (*Cinclus mexicanus*): For nesting habitat, no surface disturbance within 15-60 m (49-196 feet) (depending on stream category, per Navajo Natural Heritage Program, 1994) of occupied habitat; no activity within 0.2 km (656 feet) of active nest from March 15 to August 15; restriction zone may be less depending on activity type and duration, but not less than 0.1 km (328 feet); avoid upstream activities that affect water quantity and chemistry within occupied habitat.
- Mexican Spotted Owl (*Strix occidentalis lucida*): No habitat alteration within 40-ha (100 acre) Core Area around nest; certain silvicultural treatments may occur from September 1 to February 28 within remainder of 243-ha (600 acre) Protected Activity Center (PAC) as per Recovery Plan for the Mexican spotted owl, pp.84-89. No activity within 0.4 km (0.25 mi) of known nest/roost site during March 1 to August 31, or within 0.4 km of PAC if nest/roost site unknown.
- Northern Goshawk (*Accipiter gentilis*): No activity within 0.4 km (0.25 mi) of nest site during March 1 to August 15; no habitat alteration year-round within 0.2 km of nest site (=12 ha or 30 acre).

- Burrowing Owl (*Athene cunicularia*): No activity within 0.4 km (0.25 mi) of active nest burrow during March 1 to August 15; no habitat alteration year-round within 0.2 km (656 feet) of nest site.
- Mountain Plover (*Charadrius montanus*): No ground-disturbance activities within occupied habitat during April 1to July 15; when nest is found, delay project for 37 days, within 0.2 km (656 feet mi) of active nest with eggs or delay 7 days if brood of flightless chicks observed (per US Fish & Wildlife, 1999).
- Yellow Warbler (*Dendroica petechia*): No activity within 0.2 km (656 feet) of active nest from April 15 to July 31; extreme disturbances (e.g. blasting) may require larger restriction zone; no alteration of suitable habitat year-round within 0.2 km (656 feet) of habitat patches used for breeding, or potential habitat until surveyed.
- Hammond's Flycatcher (*Empidonax hammondii*): No activity within 0.2 km (656 feet) of active nest during May 15 to August 15; restriction zone may be less depending on activity type and duration, but not less than 0.1 km; no habitat alteration year-round within 0.2 km (656 feet) of nest site (=12 ha or 30 acre).
- American Peregrine Falcon (*Falco peregrinus*): No activity within 0.8 km (0.5 mi) of nest during March 1 to July 31. No use of explosives within 1.6 km of nest.
- Northern Pygmy-Owl (*Glaucidium gnoma*): No activity within 0.2 km (656 feet) of nest site during April 1 to August 15; no habitat alteration year-round within 0.2 km (656 feet) of nest site (=12 ha or 30 acre).
- Flammulated Owl (*Otus flammeolus*): No activity within 0.2 km(656 feet) of nest site during May 1 to August 15; no habitat alteration year-round within 0.2 km (656 feet) of nest site (=12 ha or 30 acre).
- Banded-Tailed Pigeon (*Patagioenas fasciata*): No activity within 0.2 km (⅛ mi) of active nest site during May 1 to August 1; restriction zone may be less depending on activity type and duration, but not less than 0.1 km (328 feet); no habitat alteration year-round within 0.2 km (656 feet) of nest site (=12 ha or 30 acre).
- Sora (*Porzana carolina*): For nesting habitat, no surface disturbance within 60 m of lakes and Category I wetlands and 45 m of Category II wetlands, per Navajo Natural Heritage Program (1994); no activity within 0.2 km (656 feet) of active nest during May 1 to August 1; restriction zone may be less depending on activity type and duration, but not less than 0.1 km (328 feet).
- Tree Swallow (*Tachycineta bicolor*): No activity within 0.2 km (656 feet) of active nest site during May 1 to August 1; restriction zonemay be less depending on activity type and duration, but not less than 0.1 km (328 feet); no habitat alteration year-round within 0.2 km (656 feet) of nest site (=12 ha or 30 acre).
- Gray Vireo (*Vireo vicinior*): No activity within 0.2 km (656 feet) of active nest site during May 1 to August 31; restriction zone may be less depending on activity type and duration, but not less than 0.1 km (328 feet); no habitat alteration year-round within 0.2 km (656 feet) of nest site (=12 ha or 30 acre).

Plants

- Aztec Gilia (*Aliciella formosa*): A 200-foot zone is recommended to avoid disturbance; may be more or less depending on size and nature of the project.
- San Juan Milkweed (*Asclepias sanjuanensis*): A 200-foot zone is recommended to avoid disturbance; may be more or less, depending on slope, size and nature of the project.
- Heil's Milkvetch (*Astragalus heilii*): A 200-foot zone is recommended to avoid disturbance; may be more or less depending on size and nature of the project.
- Clover's Cactus (*Sclerocactus cloverae*): A 200-foot zone is recommended to avoid disturbance; may be more or less depending on size and nature of the project.

- Mancos Milkvetch (*Astragalus humillimus*): A 200-foot zone is recommended to avoid disturbance; may be more or less depending on size and nature of the project.
- Zuni Fleabane, Rhizome Fleabane (*Erigeron rhizomatus)*: A 200-foot zone is recommended to avoid disturbance; may be more or less, depending on slope, size and nature of the project.
- Mesa Verde Cactus (*Sclerocactus mesae-verdae*): A 200-foot bufer zone is recommended to avoid disturbance; may be more or less, depending on slope, size, and nature of the project.
- Naturita Milkvetch (*Astragalus naturitensis*): A 200-foot zone is recommended to avoid disturbance; may be more or less, depending on slope, size and nature of the project.
- Navajo Bladderpod (*Lesquerella navajoensis*): A 200-foot zone is recommended to avoid disturbance; may be more or less, depending on slope, size and nature of the project.

Amphibian/Snake

- Northern Leopard Frog (*Lithobates pipiens*): Within occupied habitat, no surface disturbance (year-round) within 60 m (196 feet) of lakes, 15-60 m (49-196 feet) of streams (depending on stream category, per Navajo Natural Heritage Program, 1994), or 60 m (196 feet) of wetlands; and avoid upstream activities that impact water quantity and chemistry
- Milk Snake (*Lampropeltis triangulum*): No surface disturbance within occupied habitat that could result in take of individuals or habitat alteration

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Appendix D

Restrictions Applicable to Bureau of Land Management Fluid Mineral Leasing

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ACRONYMS AND ABBREVIATIONS — Full Phrase

Acronym	Full Phrase
ACEC	area of critical environmental concern
APD	application for permit to drill
BLM	United States Department of the Interior, Bureau of Land Management
BMP	best management practice
BOR	United States Department of the Interior, Bureau of Reclamation
CCNHP	Chaco Culture National Historical Park
COA	condition of approval
CSU	controlled surface use
dBA	a-weighted decibel(s)
EIS	environmental impact statement
ESA	Endangered Species Act of 1973
FFO	Farmington Field Office
NEPA	National Environmental Policy Act of 1969
NHT	National Historic Trail
NL	no leasing
NPS	United States Department of the Interior, National Park Service
NRHP	National Register of Historic Places
NSO	no surface occupancy
PFC	proper functioning condition
PFYC	potential fossil yield classification
RMP	resource management plan
RMPA	resource management plan amendment
ROD	record of decision
ROW	right-of-way
SDA	specially designated area
TCP	traditional cultural property
TL	timing limitation
USFWS	United States Fish and Wildlife Service
VRM	visual resource management
WSA	wilderness study area

Appendix D. Restrictions Applicable to Bureau of Land Management Fluid Mineral Leasing

This appendix lists, by alternative, the stipulations for leasing fluid minerals, such as oil and gas, referred to throughout this draft RMPA and EIS. Stipulations would also apply, where appropriate, to all surface-disturbing activities (and occupancy) associated with land use authorizations, permits, and leases issued on BLM-managed lands. The stipulations would not apply to activities and uses where they are contrary to laws, regulations, or specific program guidance.

NSO, CSU, and TL are stipulation decisions and apply to fluid mineral leasing and development of federal mineral estate underlying BLM-managed lands, Navajo Tribal trust lands, privately owned lands, state-owned lands, and lands administered by other federal agencies, such as the BOR.

Federal mineral estate acres are greater than BLM-managed surface acres. In the planning area, the BLM manages approximately 1.3 million acres of federal mineral estate beneath BLM-managed surface and 2.2 million acres of federal mineral estate beneath non-BLM-managed surface. Acreages are calculated based on current information and may be adjusted in the future through plan maintenance as conditions warrant.

TLs are restriction decisions and apply to other surface-disturbing activities on BLM-managed surface lands.

D.1 Description of Stipulations Applicable to Fluid Mineral Leasing

Tables D-1 through **D-3** provide details of the stipulations and protected resources by alternative. Each stipulation has been assigned a number for reference. Those stipulations that were developed in the 2003 RMP retained their original numbering: for instance, OG-A-4 is an NSO stipulation developed in 2003 and applied to this amendment. New stipulations have been given a new naming system: for instance, NSO-1 is an NSO developed in the 2019 RMPA/EIS process. Three types of stipulations could be applied to fluid mineral leases: NSO, CSU, and TL. Although not a stipulation, areas that are closed to fluid mineral leasing are also shown in **Table D-1**. In areas closed to leasing, the resource would not be available for exploration or development. All other areas not identified in **Table D-1** are open to fluid mineral leasing, subject to standard terms and conditions and NSO, CSU, or TL stipulations, if applicable.

Applicable lease stipulations and lease notices would be applied to all new leases and to expired leases that are reissued. On existing leases, the BLM would seek voluntary compliance, perform site-specific NEPA analysis for plan conformance, or develop COAs for APDs (pursuant to Onshore Order No. 1 [Onshore Oil and Gas Operations; Federal and Indian Oil and Gas Leases; Approval of Operations]) to achieve resource objectives of lease stipulations contained in this RMP.

Stipulations identified in the No Action Alternative were developed in the 2003 FFO RMP, and their identifiers are italicized in the "Stipulation Number" column of the tables.

D.1.1 Standard Terms and Conditions for Fluid Mineral Leasing

Oil and gas development is subject to standard terms and conditions of the lease. A number of such terms can be found in the Fluid Minerals Lease Form 3100-11. In addition, BLM fluid mineral leasing regulations (43 CFR 3101.1-2) give the BLM the ability to relocate proposed operations up to 656 feet (200 meters) and to prohibit surface-disturbing operations for a period not to exceed 60 days.

D.1.2 No Surface Occupancy

The following are prohibited, to protect identified resource values (**Table D-1**):

- Use or occupancy of the land surface for fluid mineral exploration or development
- All activities associated with fluid mineral leasing, such as truck-mounted drilling, using stationary drill rigs in unison, using geophysical exploration equipment off designated routes, and constructing wells or pads

The NSO stipulation is a category of major constraints. NSO areas are open to fluid mineral leasing, but surface occupancy or surface-disturbing activities associated with fluid mineral leasing cannot be conducted on the surface of the land. Access to leased fluid mineral deposits would require directional or horizontal drilling or drilling from outside the boundaries of the NSO area. This differs from areas identified as closed to leasing (NL) in which neither the surface area nor mineral estate is available for fluid mineral leasing.

D.1.3 Controlled Surface Use

CSU is a category of moderate constraint stipulations that allows some use and occupancy of public land while protecting identified resources or values. It is applicable to fluid mineral leasing and all activities associated with fluid mineral leasing, such as truck-mounted drilling, stationary drill rigs in unison, geophysical exploration equipment off designated routes, and construction of wells or pads. CSU areas are open to fluid mineral leasing, but the stipulation allows the BLM to require special operational constraints, or the activity can be shifted more than 656 feet (200 meters) to protect the specified resource or value. Refer to **Table D-2**.

D.1.4 Timing Limitations

Areas identified for TLs, a moderate constraint, are closed to fluid mineral exploration and development, surface-disturbing activities, and intensive human activity during identified time frames that may exceed 60 days. This stipulation does not apply to operation and basic maintenance, including associated vehicle travel, unless otherwise specified.

Construction, drilling, completions, and other operations considered to be intensive are not allowed. Intensive maintenance, such as workovers on wells, is not permitted. Administrative activities are allowed, at the discretion of the BLM Authorized Officer. Refer to **Table D-3**.

Figures D-1 through **D-5**, in **Table D-3**, show the wildlife TLs SDAs for each alternative. **Figures D-6**, **D-7**, and **D-8**, after **Table D-3**, show the unmapped wildlife TLs for each alternative.

D.1.5 Lease Notices

Lease notices are attached to leases at the time of issuance to provide more detailed information concerning limitations on oil and gas leasing and development that already exist in law, lease terms, regulations, or operational orders. These notices address special items that the lessee should consider when planning operations, but they do not impose new or additional restrictions. Refer to **Table D-4**.

D.1.6 Conditions of Approval

COAs are conditions or provisions (requirements) under which an APD is approved, after a lease is issued. COAs are based on site-specific NEPA analysis and are designed to minimize, mitigate, or prevent specific impacts on resource values or other uses of public lands. The application of a particular COA is not an RMP-level decision. Refer to **Appendix C**.

D.1.7 Project Mitigation and Monitoring

Stipulations are designed to provide resource-specific protections. Permit holders are responsible for the monitoring and reporting deemed necessary to document and maintain mandated protective measures. Also, the BLM retains the right to modify the operations of all surface and other disturbance activities caused by the presence of humans. The agency also can require additional specific or specialized mitigation after a permit applicant submits a detailed plan of development or other project proposal, a monitoring report, and an environmental analysis of such.

D.1.8 Stipulations from Other Surface Management Agencies

The BLM would also apply stipulations that have been developed by other surface management agencies that manage surface lands over BLM-managed federal mineral estate. Before issuing a lease on BLM-managed federal mineral estate beneath other SMA surface, the BLM requests consent to lease from the SMA, along with any stipulations the SMA requires. The BLM does not make decisions on what stipulations are applied in these areas.

The following stipulation has been developed by the BOR to apply to any leases on BLM-managed federal mineral estate in the vicinity of BOR dams: No surface occupancy or use is allowed within 1,500 feet of all BOR dams (e.g., Navajo and Cutter Dams) and their appurtenant structures.

The stipulation listed above does not represent all stipulations that may be applied. For example, leases in Navajo Lake State Park would be subject to consent and any stipulations required by the BOR, which manages the area, in conjunction with the New Mexico State Parks Department. These stipulations may change at the discretion of the SMA.

D.2 Exceptions, Modifications, and Waivers Applicable to Fluid Mineral Leasing

Stipulations could be excepted, modified, or waived by the BLM Authorized Officer where reasonable in light of changing circumstances. For lands where the BLM manages the mineral estate but not the surface, a stipulation may be excepted, waived, or modified based on the wishes of the surface owner (including Navajo Nation and Navajo individual Indian allottees). Exceptions, modifications, and waivers provide a viable and effective means of applying adaptive management techniques to fluid mineral leasing or other surface-disturbing activities. If the BLM Authorized Officer determined, before the lease was issued, that a stipulation involves an issue of major concern to the public, its modification or waiver would be subject to public review for at least 30 days.

D.2.1 Standard Exception, Modification, and Waiver

The standard exception, modification, and waiver apply to all NSOs, CSUs, and TLs, unless otherwise stated.

An exception is a one-time exemption for a particular site in the leasehold or project area and is determined on a case-by-case basis. The stipulation continues to apply to all other sites in the leasehold. The BLM Authorized Officer may grant an exception to a stipulation if the factors leading to its inclusion in the lease have changed sufficiently such that 1) the protection provided by the stipulation is no longer justified or necessary to meet resource objectives established in the RMP; or 2) proposed operations would not cause unacceptable impacts.

The BLM Authorized Officer may require additional plans of development, surveys, mitigation proposals, or environmental analysis. He or she may be required to consult with other government agencies or the public in order to make determinations regarding exceptions.

A modification is a change to the provisions of a lease stipulation or project, either temporarily or for the lease term or length of the project. Depending on the specific modification, the stipulation may or may not apply to all sites in the leasehold to which the restrictive criteria are applied.

The BLM Authorized Officer may modify a stipulation or the area subject to the stipulation if it is determined that the factors leading to its inclusion in the lease have changed sufficiently. The BLM Authorized Officer may modify a stipulation as a result of new information under the following situations:

- If the protection provided by the stipulation is no longer justified or necessary to meet resource objectives established in the RMP
- If the protection provided by the stipulation is no longer sufficient to meet resource objectives established in the RMP
- If proposed operations would not cause unacceptable impacts

The BLM Authorized Officer may require additional plans of development, surveys, mitigation proposals, or environmental analysis. He or she may be required to consult with other government agencies or the public in order to make this determination. The modification may be subject to public review for at least 30 days.

A waiver permanently exempts the surface stipulation throughout the lease or project area. The stipulation no longer applies anywhere in the leasehold. The BLM Authorized Officer may waive a stipulation if it is determined that the factors leading to its inclusion in the lease no longer exist. The BLM Authorized Officer may require additional plans of development, surveys, mitigation proposals, or environmental analysis. He or she may be required to consult with other government agencies or the public in order to make this determination. The waiver may be subject to public review for at least 30 days.

The environmental analysis document prepared for site-specific proposals, such as oil and gas development (e.g., APDs and sundry notices) or other surface projects also needs to address a proposal to except, modify, or waive a surface stipulation. For lands where the BLM manages the mineral estate but not the surface, a stipulation may be excepted, waived, or modified based on the wishes of the surface owner (including the Navajo Nation and Navajo individual Indian allottees).

Table D-1
No Surface Occupancy Stipulations Applicable to Fluid Mineral Leasing

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
	Specially Designated Areas					
OG-A-4 *Specially Designated Areas* No Action Alternative: BLM surface/federal fluid minerals: 34,000 acres Non-BLM surface/federal fluid minerals: 3,300 acres Alternative A: BLM surface/federal fluid minerals: 142,800 acres Non-BLM surface/federal fluid minerals: 15,100 acres Alternative B: BLM surface/federal fluid minerals: 77,500 acres Non-BLM surface/federal fluid minerals: 3,300 acres Alternative C: BLM surface/federal fluid minerals: 44,600 acres Non-BLM surface/federal fluid minerals: 4,900 acres	No surface occupancy or use is allowed on lands within ACECs, recreation/natural/wildlife areas, and scenic areas. **PURPOSE:** To protect sensitive resources within SDAs, including designated ACECs, wildlife, scenic, and recreation areas **WAIVER:** None **EXCEPTION:** Exceptions within threatened or endangered species habitat would be allowed only if the US Fish and Wildlife concurs that there would be no adverse effect on listed species or their habitat. An exception may be granted on a case-by-case basis within cultural ACECs if wells are collocated or twinned and existing surface disturbance is used. **MODIFICATION:** None See **Chapter 2**, **Table 2-3**, NSO for Specially Designated Areas, for specific areas that would be subject to this stipulation.	✓	✓	✓	✓	✓

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative: No Action	A	B	C	D
Alternative D: BLM surface/federal fluid minerals: 34,000 acres Non-BLM surface/federal fluid minerals: 3,300 acres						
Cultural Resources						
NSO-1 *Chaco Cultural Zone* BLM surface/federal fluid minerals: 112,800 acres Non-BLM surface/federal fluid minerals: 66,700 acres	No surface occupancy or use is allowed from miles 2 to 4 around the CCNHP boundary and from miles 2 to 3 around designated Chacoan roads (including those in and outside of ACECs) and outliers. **PURPOSE:** In order to minimize visual, noise, and vibration impacts on CCNHP—a designated World Heritage site—and its outliers **WAIVER:** None **EXCEPTION:** An exception may be granted if the lessee submits a plan of development (POD) and the NEPA analysis determines visual, noise and vibration impacts can be minimized as to not adversely affect resource values (roads, outliers and other sites associated with CCNHP). **MODIFICATION:** None		✓			

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
NSO-2 *Chaco Cultural Zone* BLM surface/federal fluid minerals: 244,400 acres Non-BLM surface/federal fluid minerals: 132,800 acres	No surface occupancy or use is allowed from miles 3 to 5 around designated Chacoan roads (including those in and outside of ACECs) and outliers. **PURPOSE:** In order to minimize visual, noise, and vibration impacts on CCNHP—a designated World Heritage site—and its outliers **WAIVER:** None **EXCEPTION:** An exception may be granted if the lessee submits a POD and the NEPA analysis determines visual, noise, and vibration impacts can be minimized as to not adversely affect resource values (roads, outliers, and other sites associated with CCNHP). **MODIFICATION:** None			✓		
NSO-3 *Chaco Cultural Zone* BLM surface/federal fluid minerals: 3,400 acres Non-BLM surface/federal fluid minerals: 10,700 acres	No surface occupancy or use is allowed for 1 mile around Chacoan outliers other than Pueblo Pintado and Kin Bineola, for 0.5 miles on either side of the ACEC boundary for Chacoan road ACECs, including the North Road ACEC and Ah-shi-sle-pah Road ACEC, and for 0.75 miles on either side of the center line of designated Chacoan roads that are not in ACECs. **PURPOSE:** In order to minimize visual, noise, and vibration impacts on roads, outliers, and other sites associated with CCNHP, a designated World Heritage Site **WAIVER:** None **EXCEPTION:** An exception may be granted if the lessee submits a POD and the NEPA analysis determines visual, noise, and vibration impacts can be minimized as to not adversely affect resource values (roads, outliers, and other sites associated with CCNHP). **MODIFICATION:** None				✓	
NSO-4 through NSO-9	These apply to BLM Sub-Alternatives C1-C6. See **Table D-2**, below.				✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
NSO-10 *CIMPPs and Historic Properties*	No surface occupancy or use within 3,696 feet (0.7 miles) of CIMPPs and historic properties for which setting or feeling are important aspects of integrity. **PURPOSE:** Protection of known cultural resource values and/or traditional cultural properties in areas not already within ACECs to reduce the risk of damage to cultural resources resulting from surface disturbance and to preserve the cultural setting of those resources by reducing visual and noise impacts. **WAIVER:** This stipulation may be waived or reduced in scope if circumstances change or if the lessee can demonstrate that operations can be conducted without causing unacceptable impacts on the concern(s) identified. **EXCEPTION:** An exception could be granted if the BLM Authorized Officer determines that 1) avoidance of direct and indirect impacts on historic properties is not feasible (e.g., avoidance may cause unacceptable damage to other public land resources or affect valid existing rights), 2) the project would benefit important cultural or historic values, 3) the project would be in the public interest, or 4) the visual and noise impacts can be adequately mitigated to protect the setting of the resource. **MODIFICATION:** The BLM Authorized Officer may modify the site-protection boundary on a case-by-case basis after completion and documentation of Section 106 consultation including with Tribes, and/or consultation with the affected Tribes and users of CUSPs, as appropriate, taking into account topographical barriers, the design of the proposed action, and the characteristics of the cultural resource site and/or area.		✓		✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
NSO-11 *CIMPPs and Historic Properties*	No surface occupancy or use within 1.75 miles of CIMPPs and historic properties for which setting or feeling are important aspects of integrity. **PURPOSE:** Protection of known cultural resource values and/or traditional cultural properties in areas not already within ACECs to reduce the risk of damage to cultural resources resulting from surface disturbance and to preserve the cultural setting of those resources by reducing visual and noise impacts. **WAIVER:** This stipulation may be waived or reduced in scope if circumstances change or if the lessee can demonstrate that operations can be conducted without causing unacceptable impacts on the concern(s) identified. **EXCEPTION:** An exception could be granted if the BLM Authorized Officer determines that 1) avoidance of direct and indirect impacts on historic properties is not feasible (e.g., avoidance may cause unacceptable damage to other public land resources or affect valid existing rights), 2) the project would benefit important cultural or historic values, 3) the project would be in the public interest, or 4) the visual and noise impacts can be adequately mitigated to protect the setting of the resource. **MODIFICATION:** The BLM Authorized Officer may modify the site-protection boundary on a case-by-case basis after completion and documentation of Section 106 consultation, including with Tribes, and/or consultation with the affected Tribes and users of CUSPs, as appropriate, taking into account topographical barriers, the design of the proposed action, and the characteristics of the cultural resource site and/or area.			✓		

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
Geologic Resources						
F-23 *Beechatuda Tongue* BLM surface/federal fluid minerals: 100 acres Non-BLM surface/federal fluid minerals: 0 acres	No surface occupancy or use is allowed on the lands described below: Beechatuda Tongue: on portions of T. 30 N., R. 15 W., Section 5: NW1/4 (100 acres) to preserve the unit to be studied for stratigraphic nomenclature and to preserve the unique geological formation. **PURPOSE:** The Beechatuda Tongue of the Cliff House Sandstone is a rock stratigraphic unit mapped in, and named for, Beechatuda Draw in T. 30 N., R. 15 W., Section 5: NW¼. This area is the type locality for the unit; as such, it is of interest to scientists and educators as a site for comparison and study of the unit and for possible further refinement of the stratigraphic nomenclature. It is important that the unit be preserved intact to allow these studies. **WAIVER:** None **EXCEPTION:** An exception may be granted if existing disturbance would be used and the BLM Authorized Officer determines that occupancy would not damage or otherwise adversely affect the unit. **MODIFICATION:** None	✓	✓	✓	✓	✓
Soil Resources						
NSO-12 *Fragile Soils* BLM surface/federal fluid minerals: 404,100 acres Non-BLM surface/federal fluid minerals: 62,900 acres	No surface occupancy or use is allowed on fragile soils. **PURPOSE:** To maintain soil productivity and provide necessary protection to prevent excessive soil erosion on steep slopes, slope failure, mass wasting, and excessive reclamation challenges **WAIVER:** None **EXCEPTION:** If the operator can demonstrate that the soil can be stabilized through design features to maintain the soil productivity and minimize erosion, the BLM Authorized Officer may approve an exception. **MODIFICATION:** None		✓	✓		

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
Water Resources						
NSO-13 *Domestic wells and community waters* BLM surface/federal fluid minerals: 5,300 acres Non-BLM surface/federal fluid minerals: 20,200 acres	No surface occupancy or use within 1,000 feet (0.2 miles) of all domestic water wells or community water sources (including those that have not been permitted by the State of New Mexico). Directional drilling may be prohibited to protect water quality, depending on site-specific analysis. **PURPOSE:** For the purpose of protecting, maintaining, and enhancing the groundwater resources **WAIVER:** None **EXCEPTION:** An exception to the setback portion of this stipulation may be granted on a case-by-case basis, when engineering and best available science have demonstrated that the same amount of protection can be applied with a lesser buffer, or if the operator can show that operations can be conducted without adversely affecting the protected resources. Examples of actions that could be used to demonstrate protection include, but are not limited to, closed-loop systems are being employed and the minimum casing length requirement of 500 feet is met. A spill prevention and leak detection plan and appropriate spill prevention equipment (leak detection and automatic shutoff system) is required for all wells, facilities, and pipelines within 1,000 feet (0.2 miles) of domestic water wells and community waters. **MODIFICATION:** None		✓		✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
Vegetation						
NSO-14 *Ephemeral Wash* BLM surface/federal fluid minerals: 40,300 acres Non-BLM surface/federal fluid minerals: 3,200 acres	No surface occupancy or use is allowed on active floodplains in the Ephemeral Wash Riparian Area to protect riparian systems and facilitate attainment and maintenance of PFC. **PURPOSE:** To maintain healthy riparian areas that are in a productive, properly functioning, and sustainable condition, within the capability of each site **WAIVER:** None **EXCEPTION:** Exceptions, which are subject to CSU (site-specific relocation) stipulations, are as follows: Essential future actions in which implementation of a professionally engineered design, construction, maintenance, and reclamation plan can mitigate to the fullest extent practicable all potential resource damage. **MODIFICATION:** None	✓				
NSO-15 *Riparian System* BLM surface/federal fluid minerals: 771,500 acres Non-BLM surface/federal fluid minerals: 414,600 acres	No surface occupancy or use allowed within the active channel, 100-year floodplain, and a 656-foot zone around the outside boundary of all 100-year floodplains and riparian systems, including the Ephemeral Wash Riparian Area. **PURPOSE:** To maintain healthy riparian areas that are in a productive, properly functioning, and sustainable condition, within the capability of each site **WAIVER:** None **EXCEPTION:** None **MODIFICATION:** None		✓			

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
NSO-16 *Riparian System* BLM surface/federal fluid minerals: 230,900 acres Non-BLM surface/federal fluid minerals: 142,000 acres	No surface occupancy or use is allowed within the active channel, 100-year floodplain, and a 150-foot zone around the outside boundary of all 100-year floodplains and riparian systems, including, but not limited to the Ephemeral Wash Riparian Area. **PURPOSE:** To maintain healthy riparian areas that are in a productive, properly functioning, and sustainable condition, within the capability of each site **WAIVER:** None **EXCEPTION:** None **MODIFICATION:** None			✓		
NSO-17 *Wetlands*	No surface occupancy or use is allowed in wetland areas (as defined in the Corps of Engineers Wetlands Delineation Manual [USACE 1987]). **PURPOSE:** To manage and protect wetland areas so as to maintain proper functioning condition, provide for groundwater recharge, provide habitat, and assist in meeting state and Tribal water quality standards **WAIVER:** A waiver may be granted if it is determined that the area does not qualify as a riparian area or a wetland. **EXCEPTION:** On a case-by-case basis, some infrastructure may be permitted if it falls within an existing corridor for the purposes of crossing the wetland area only. For example, a pipeline may be permitted if it is bored beneath the area in question and/or constructed next to an existing pipeline. **MODIFICATION:** None	✓				

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
NSO-18 *Wetlands and Seeps/Springs* BLM surface/federal fluid minerals: 771,500 acres Non-BLM surface/federal fluid minerals: 414,600 acres	No surface occupancy or use is allowed within 656 feet (200 meters) of the delineated boundary or ordinary high-water mark of known and newly discovered wetlands and natural seeps/springs. A 500-foot minimum casing length is required for all wells. Directional drilling may be prohibited to protect water quality beneath wetlands or seeps/springs, depending on site-specific analysis. **PURPOSE:** To manage and protect wetland areas so as to maintain proper functioning condition, provide for groundwater recharge, provide habitat, and assist in meeting state and tribal water quality standards **WAIVER:** A waiver may be granted if it is determined that the area does not qualify as a riparian area or a wetland. **EXCEPTION:** A one-time exception may be granted for ephemeral washes or canyons that are less than 656 feet (200 meters) wide under circumstances in which a geological formation or natural barriers would otherwise prevent accessing the lease. On a case-by-case basis, some infrastructure may be permitted if it falls within an existing corridor for the purposes of crossing the wetland area only. For example, a pipeline may be permitted if it is bored beneath the area in question and/or constructed next to an existing pipeline. **MODIFICATION:** None		✓			

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
NSO-19 *Wetlands and Seeps/Springs* BLM surface/federal fluid minerals: 222,700 acres Non-BLM surface/federal fluid minerals: 136,500 acres	No surface occupancy or use within 150 feet of the delineated boundary or ordinary high-water mark of known and newly discovered wetlands and natural seeps/springs. A 500-foot minimum casing length is required for all wells. **PURPOSE:** To manage lentic and lotic areas to maintain proper functioning condition, protect these areas for human use/visitor experience and for their unique contribution to the desert environment and assist in meeting state and tribal water quality standards **WAIVER:** A waiver may be granted if it is determined that the area does not qualify as a riparian area or a wetland. **EXCEPTION:** A one-time exception may be granted for ephemeral washes or canyons that are less than 656 feet (200 meters) wide under circumstances in which a geological formation or natural barriers would otherwise prevent accessing the lease. On a case-by-case basis, some infrastructure may be permitted if it falls within an existing corridor for the purposes of crossing the wetland area only. For example, a pipeline may be permitted if it is bored beneath the area in question and/or constructed next to an existing pipeline. **MODIFICATION:** None			✓		

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative: No Action	A	B	C	D
NSO-20 *Plant Conservation Areas* Alternative A: BLM surface/federal fluid minerals: 6,800 acres Non-BLM surface/federal fluid minerals: 0 acres	No surface occupancy or use in designated plant conservation areas. **PURPOSE:** To protect sensitive resources, including Clover's cactus and Aztec gilia, in plant conservation areas **WAIVER:** None **EXCEPTION:** Exceptions may be granted by the BLM Authorized Officer for activities where no other feasible alternatives are available, efforts to avoid and minimize habitat loss are demonstrated sufficiently, and losses of population numbers comprise less than 5% of total population present in the action area. Mitigation can be applied to achieve a no net loss situation for habitat. **MODIFICATION:** None		✓			
Special Status Species						
NSO-21 *Yellow-billed Cuckoo and Southwestern Willow Flycatcher Nesting Habitat*	No surface occupancy or use is allowed in identified potential yellow-billed cuckoo and southwestern willow flycatcher nesting habitat. **PURPOSE:** Ensuring the protection of threatened and endangered species and their habitat, and no net loss of potential southwestern willow flycatcher habitat from oil and gas development or other ground-disturbing activities **WAIVER:** None **EXCEPTION:** No exceptions are allowed within the active floodplain. Exceptions within threatened or endangered species habitat may be allowed only if the operator demonstrates there would be no negative impacts on listed species and their habitat and the USFWS concurs that there would be no adverse effect. **MODIFICATION:** None		✓	✓	✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
NSO-22 *Mexican Spotted Owl*	No surface occupancy or use is allowed within all Mexican spotted owl suitable habitat (i.e., mixed conifer forests, pine-oak woodlands, and shady wooded canyons) in the Mexican Spotted Owl ACEC. **PURPOSE:** Ensuring the protection of threatened and endangered species and their habitat **WAIVER:** None **EXCEPTION:** Exceptions within threatened or endangered species habitat may be allowed only if the operator demonstrates there would be no negative impacts on listed species and their habitat and if the USFWS concurs that there would be no adverse effect. **MODIFICATION:** None		✓	✓	✓	
NSO-23 *Federally Listed Species critical habitat* BLM surface/federal fluid minerals: 3,100 acres Non-BLM surface/federal fluid minerals: 1,100 acres	No surface occupancy or use is allowed in all designated and proposed critical habitat for federally listed species. **PURPOSE:** Ensuring the protection of threatened and endangered species and their habitat, including critical habitat **WAIVER:** None **EXCEPTION:** An exception may be granted by the BLM Authorized Officer when 1) Section 7 consultation with the USFWS on threatened or endangered species has been completed and impact is accounted for in the Biological Opinion; 2) valid current surveys for protected species have been completed and submitted; 3) mitigation has been applied to avoid adverse impacts; and 4) the proposed disturbance would occur in unsuitable habitat to maintain a "no net loss" of habitat. Other surface-disturbing activities may be allowed in suitable habitat if conditions 1 through 3 are met and the purpose or the result of the activity would improve habitat conditions for the protected species. **MODIFICATION:** None		✓	✓		

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
NSO-24 *Bald Eagle Core Areas*	No surface occupancy or use shall be permitted in core areas of the Bald Eagle ACEC. **PURPOSE:** To reduce impacts from oil and gas development on bald eagle core habitat areas **WAIVER:** None **EXCEPTION:** None **MODIFICATION:** None	✓	✓	✓	✓	✓
Communities						
NSO-25 *Occupied Dwellings*	No surface occupancy or use is allowed within 1,320 feet (0.25 miles) of any house, barn, occupied dwelling, structure on a home site lease, or building unit (including those structures occupied intermittently or seasonally) or other community, municipal, and public structures and buildings, such as chapter houses and schools, and other sensitive receptors, as defined by the EPA. NSO may be adjusted, based on site-specific conditions. **PURPOSE:** To reduce the impacts of resource development on local residents and communities **WAIVER:** None **EXCEPTION:** None **MODIFICATION:** None		✓	✓		

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
NSO-26 *Occupied Dwellings*	No surface occupancy or use is allowed within 3,696 feet (0.7 miles) of any house, barn, occupied dwelling, structure on a home site lease, or building unit (including those structures occupied intermittently or seasonally) or other community, municipal, and public structures and buildings, such as chapter houses and schools, and other sensitive receptors, as defined by the EPA. NSO setback may be adjusted, based on site-specific conditions. **PURPOSE:** Reduce impacts from oil and gas development from noise, dust, and various other associated activities on local residents' and communities' quality of life and health **WAIVER:** None **EXCEPTION:** None **MODIFICATION:** None				✓	
NSO-27 *Occupied Dwellings*	No surface occupancy or use is allowed within 656 feet (200 meters) of any house, barn, occupied dwelling, structure on a home site lease, or building unit (including those structures occupied intermittently or seasonally) or within 1,000 feet of other community, municipal, and public structures and buildings, such as chapter houses and schools, and other sensitive receptors, as defined by the EPA. NSO may be adjusted, based on site-specific conditions. **PURPOSE:** To reduce the impacts from oil and gas development on local residents and communities **WAIVER:** None **EXCEPTION:** The BLM Authorized Officer may grant an exception if the operator can demonstrate best management practices (BMPs) (siting, mitigation, latest technology, etc.) and consultation to satisfy occupants' concerns about proximity to include, but not limited to, sound, dust, light, and safety. **MODIFICATION:** None					✓

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
State Parks and Wildlife Areas						
NSO-28 *Jackson Lake Wildlife Area* BLM surface/federal fluid minerals: 0 acres Non-BLM surface/federal fluid minerals: 30 acres	No surface occupancy or use within Jackson Lake Wildlife Area. **PURPOSE:** To collaborate with New Mexico state agencies, including the New Mexico Game and Fish Department, and to assist them by reducing surface impacts **WAIVER:** None, unless waived by managing agency **EXCEPTION:** None, unless excepted by managing agency **MODIFICATION:** None, unless modified by managing agency				✓	

Table D-2
No Surface Occupancy Stipulations Applicable to the Chaco Cultural Zone Under Sub-Alternatives C1 through C6

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Sub-Alternative					
		C1	C2	C3	C4	C5	C6
NSO-4 *Chaco Cultural Zone* BLM surface/federal fluid minerals: 3,500 acres Non-BLM surface/federal fluid minerals: 11,100 acres	No surface occupancy or use is allowed for 2 miles around the CCNHP boundary. **PURPOSE:** In order to minimize visual, noise, and vibration impacts on roads, outliers, and other sites associated with CCNHP, a designated World Heritage Site **WAIVER:** None **EXCEPTION:** An exception may be granted if the lessee submits a POD and the NEPA analysis determines visual, noise, and vibration impacts can be minimized as to not adversely affect resource values (roads, outliers, and other sites associated with CCNHP). **MODIFICATION:** None	✓					
NSO-5 *Chaco Cultural Zone* BLM surface/federal fluid minerals: 15,000 acres Non-BLM surface/federal fluid minerals: 31,300 acres	No surface occupancy or use is allowed for 4 miles around the CCNHP boundary. **PURPOSE:** In order to minimize visual, noise, and vibration impacts on roads, outliers, and other sites associated with CCNHP, a designated World Heritage Site **WAIVER:** None **EXCEPTION:** An exception may be granted if the lessee submits a POD and the NEPA analysis determines visual, noise, and vibration impacts can be minimized as to not adversely affect resource values (roads, outliers, and other sites associated with CCNHP). **MODIFICATION:** None		✓				

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Sub-Alternative					
		C1	C2	C3	C4	C5	C6
NSO-6 *Chaco Cultural Zone* BLM surface/federal fluid minerals: 35,900 acres Non-BLM surface/federal fluid minerals: 55,200 acres	No surface occupancy or use is allowed for 6 miles around the CCNHP boundary. **PURPOSE:** In order to minimize visual, noise, and vibration impacts on roads, outliers, and other sites associated with CCNHP, a designated World Heritage Site **WAIVER:** None **EXCEPTION:** An exception may be granted if the lessee submits a POD and the NEPA analysis determines visual, noise, and vibration impacts can be minimized as to not adversely affect resource values (roads, outliers, and other sites associated with CCNHP). **MODIFICATION:** None			✓			
NSO-7 *Chaco Cultural Zone* BLM surface/federal fluid minerals: 68,100 acres Non-BLM surface/federal fluid minerals: 78,600 acres	No surface occupancy or use is allowed for 8 miles around the CCNHP boundary. **PURPOSE:** In order to minimize visual, noise, and vibration impacts on roads, outliers, and other sites associated with CCNHP, a designated World Heritage Site **WAIVER:** None **EXCEPTION:** An exception may be granted if the lessee submits a POD and the NEPA analysis determines visual, noise, and vibration impacts can be minimized as to not adversely affect resource values (roads, outliers, and other sites associated with CCNHP). **MODIFICATION:** None				✓		
NSO-8 *Chaco Cultural Zone* BLM surface/federal fluid minerals: 112,500 acres Non-BLM surface/federal fluid minerals: 97,200 acres	No surface occupancy or use is allowed for 10 miles around the CCNHP boundary. **PURPOSE:** In order to minimize visual, noise, and vibration impacts on roads, outliers, and other sites associated with CCNHP, a designated World Heritage Site **WAIVER:** None **EXCEPTION:** An exception may be granted if the lessee submits a POD and the NEPA analysis determines visual, noise, and vibration impacts can be minimized as to not adversely affect resource values (roads, outliers, and other sites associated with CCNHP). **MODIFICATION:** None					✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Sub-Alternative					
		C1	C2	C3	C4	C5	C6
NSO-9 *Chaco Cultural Zone* BLM surface/federal fluid minerals: 20,800 acres Non-BLM surface/federal fluid minerals: 20,40 acres	No surface occupancy or use is allowed for 2 miles around the 4-mile closure area around the CCNHP boundary. **PURPOSE:** In order to minimize visual, noise, and vibration impacts on roads, outliers, and other sites associated with CCNHP, a designated World Heritage Site **WAIVER:** None **EXCEPTION:** An exception may be granted if the lessee submits a POD and the NEPA analysis determines visual, noise, and vibration impacts can be minimized as to not adversely affect resource values (roads, outliers, and other sites associated with CCNHP). **MODIFICATION:** None						✓

Table D-3
Controlled Surface Use Stipulations Applicable to Fluid Mineral Leasing

<table>
<tr><th rowspan="2">Stipulation Number (Existing/New) Protected Resource Acres Affected[1]</th><th rowspan="2">Stipulation Description</th><th colspan="5">Alternative</th></tr>
<tr><th>No Action</th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td colspan="7">Specially Designated Areas</td></tr>
<tr><td>CSU-1
Specially Designated Areas - Cultural
BLM surface/federal fluid minerals: 22,700 acres
Non-BLM surface/federal fluid minerals: 1,600 acres</td><td>Surface occupancy or use would be subject to the following special operating constraints within all or part of the seven cultural SDAs listed in the RMP:
• Surface-disturbing activities are to be restricted to identified areas to minimize disturbance and impacts.
• Existing disturbance/corridors would be used, and wells would be collocated to reduce road, pad, and utility surface disturbance.
PURPOSE: To manage cultural SDAs for the protection and preservation of cultural, visual, and natural resource values
WAIVER: None
EXCEPTION: Exceptions granted on a case-by-case basis, as determined by environmental review.
MODIFICATION: None</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>F-9
Specially Designated Areas - Paleontological
Alternatives No Action, A, B, and C:
BLM surface/federal fluid minerals: 107,400 acres
Non-BLM surface/federal fluid minerals: 16,200 acres</td><td>Surface occupancy or use would be subject to the following special operating constraints in all or part of paleontological SDAs:
• Restrict vehicles to existing roads and trails
• Require a paleontological clearance on surface-disturbing activities
PURPOSE: Protect the area for scientific study
WAIVER: None
EXCEPTION: Exceptions granted on a case-by-case basis, as determined by environmental review.
MODIFICATION: None</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
</table>

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
Alternative D: BLM surface/federal fluid minerals: 600 acres Non-BLM surface/federal fluid minerals: 0 acres	See **Chapter 2**, **Table 2-3**, CSU for SDAs, for specific areas that would be subject to this stipulation.					
CSU-2 *Specially Designated Areas - Recreation* BLM surface/federal fluid minerals: 43,800 acres Non-BLM surface/federal fluid minerals: 1,400 acres	Surface occupancy or use would be subject to the following special operating constraints in all or part of the recreation SDAs listed in the 2003 RMP: • Surface use is not allowed within 150 feet on either side of designated trail systems. • Construction, drilling, completion, plugging, seismic exploration, and workover would be not allowed when such activities would interfere with authorized recreation events. **PURPOSE:** Protect and preserve the natural, scenic, and outdoor recreation values and provide visitors with the opportunity to engage in a wide variety of high-quality recreational experiences **WAIVER:** None **EXCEPTION:** Exceptions granted on a case-by-case basis, as determined by environmental review. **MODIFICATION:** None	✓	✓	✓	✓	✓

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative: No Action	A	B	C	D
CSU-3 *Specially Designated Areas – Ephemeral Wash Riparian Area* BLM surface/federal fluid minerals: 9,800 acres Non-BLM surface/federal fluid minerals: 0 acres	Surface occupancy or use would be subject to the following special operating constraints within the Ephemeral Wash Riparian Area: Controlled surface use requiring special mitigation measures to stabilize channels in order to prevent migration of channel on to well sites may be required within the 100-year floodplain. **PURPOSE:** Protecting riparian systems and facilitating attainment and maintenance of proper functioning condition **WAIVER:** None **EXCEPTION:** Exceptions granted on a case-by-case basis as determined by environmental review. **MODIFICATION:** None	✓		✓	✓	
CSU-4 *Specially Designated Areas – Mexican Spotted Owl ACEC* BLM surface/federal fluid minerals: 2,700 acres Non-BLM surface/federal fluid minerals: 100 acres	Surface occupancy or use would be subject to the following special operating constraints within the Mexican spotted owl ACEC: • Avoid disturbance of ponderosa pine and mixed conifer forest stands • Prepare a wildfire prevention plan • Do not allow noise from oil and gas production facilities to exceed 48.6 dBA in the vicinity of identified owl nests • Adhere to the MSO Recovery Plan of 1995 and any revisions of the plan that may be completed in the future **PURPOSE:** Protect Mexican spotted owl critical habitat, as designated by the USFWS **WAIVER:** None **EXCEPTION:** Exceptions granted on a case-by-case basis, as determined by environmental review. **MODIFICATION:** None	✓	✓	✓	✓	✓

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative: No Action	A	B	C	D
F-45-CSU *Specially Designated Areas – Wildlife* BLM surface/federal fluid minerals: 283,400 acres Non-BLM surface/federal fluid minerals: 64,400 acres	Surface occupancy or use would be subject to, but not limited to, the following constraints within wildlife SDAs: • Utilization of existing oil and gas related surface disturbance will be required for all new well, road and related infrastructure proposals. Proposals in previously undisturbed areas or areas where two track roads have been retired will only be considered if mitigation, such as directional or horizontal drilling, gated enclosures, and water or forage development, as evaluated by the BLM through the NEPA analysis, can adequately offset disturbance. • Directional or horizontal drilling will be considered as a method of development and analyzed in the environmental assessment as the proposed action or an alternative to the proposed action. Proposals using vertical drilling will only be approved if mitigation, such as gated enclosures and water or forage development, as evaluated by the BLM through the NEPA analysis, can adequately offset disturbance. • Operators are encouraged to incorporate Best Management Practices, such as direction or horizontal drilling, erosion control, reclamation practices, into the design features of the Surface Use Plan of Operations to minimize impacts to the wildlife habitat. However, additional mitigation, based on the environmental analysis, will most likely be required and attached to the proposed action as Conditions of Approval. **PURPOSE:** Manage the wildlife SDAs to protect wildlife and preserve their habitat **WAIVER:** None **EXCEPTION:** Exceptions granted on a case-by-case basis, as determined by environmental review. **MODIFICATION:** None See **Chapter 2**, **Table 2-3**, CSU for SDAs, for specific areas that would be subject to this stipulation.	✓				
CSU-5 *Specially Designated Areas – Wildlife* Alternative A:	Per the direction of: **Farmington Resource Management Plan** (155+): • The FFO BLM is directed to ensure optimum populations, natural abundance, and diversity of fish and wildlife values by restoring, maintaining, and enhancing habitat conditions for consumptive and non-consumptive uses…		✓	✓	✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
BLM surface/federal fluid minerals: 96,400 acres Non-BLM surface/federal fluid minerals: 10,800 acres Alternative B: BLM surface/federal fluid minerals: 130,600 acres Non-BLM surface/federal fluid minerals: 10,900 acres Alternative C: BLM surface/federal fluid minerals: 262,800 acres Non-BLM surface/federal fluid minerals: 59,000 acres	**SO 3362:** 1) Directs the BLM to better plan and manage Department's land to protect and conserve habitat and migration corridors for wildlife 2) Directs the BLM to evaluate and appropriately apply site-specific management activities that conserve or restore habitat necessary to sustain local and regional big-game populations through measures that may include one or more of the following: o avoiding development in the most crucial winter range or migration corridors during sensitive seasons o minimizing development that would fragment winter range and primary migration corridors o limiting disturbance of big game on winter range o using other proven actions necessary to conserve and/or restore the vital big-game winter range and migration corridors across the West The listed wildlife SDAs possess quality habitat for mule deer, antelope, black bear, elk, Merriam's turkey, and Pinyon Jays. Considerable effort has been expended to improve this habitat. Additional research and surveys are continuously informing and identifying new critical migration corridors and habitat. As a consequence, the unique habitat contained within these wildlife areas as well as any additional areas determined to be important migration corridors or habitat by new information (e.g., NMDGF research) are subject to, but may not be limited to the following controlled surface use provisions (see Farmington RMP [BLM 2003]). • Utilization of existing oil and gas related surface disturbance will be required for all new well, road and related infrastructure proposals. Proposals in previously undisturbed areas or areas where two track roads have been retired will only be considered if mitigation, such as off-site facilities, gated enclosures, and water or forage development, as evaluated by the BLM through the NEPA analysis, can adequately offset disturbance and the proposal meets the waiver, exception, or modification criteria. • Reasonable alternative locations and routes that minimize impacts will be considered and analyzed in the environmental assessment as the proposed action or an alternative to the proposed action. Proposals outside of existing disturbance will only be approved if mitigation, such as gated enclosures, road closures and reclamation, off-site facilities, and water or forage					

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
	development, as evaluated by the BLM through the NEPA analysis, can adequately offset disturbance and the proposed action meets the waiver, exception, or modification criteria. • Operators are encouraged to incorporate BMPs, such as directional or horizontal drilling, twinning or co-locating, erosion control, and reclamation practices, into the design features of the Surface Use Plan of Operations to minimize impacts on the wildlife habitat. However, additional mitigation, based on the environmental analysis, will most likely be required and attached to the proposed action as COAs. **PURPOSE:** Manage the wildlife SDAs to protect wildlife and preserve their habitat **WAIVER:** None **EXCEPTION:** Conserving and maintaining migration corridors as well as contiguous patches of habitat with sustainable range, refuge, and connectivity is priority. In such, proposals in undisturbed areas within habitat patches identified by the FFO through analysis that are greater than 30 acres or that display importance to migration paths will not be considered. If habitat patches are less than 30 acres and if it can be demonstrated that oil and gas operations through mitigation such as gated enclosures, road closures and reclamation, off-site facilities, and water or forage development can be conducted to mitigate impacts, an exception may be granted by the BLM Authorized Officer. An exception of this stipulation may require NEPA analysis. If the BLM Authorized Officer determines that the exception involves an issue of major public concern, it shall be subject to a 30-day public review period. Any changes to this stipulation will be made in accordance with the land use plan and or the regulatory provisions for such changes. **MODIFICATION:** None See **Chapter 2**, **Table 2-3**, CSU for SDAs, for specific areas that would be subject to this stipulation.					

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
	Soil Resources					
F-46-CSU *Steep Slopes* BLM surface/federal fluid minerals: 674,000 acres Non-BLM surface/federal fluid minerals: 189,100 acres	F-46-CSU: Surface-disturbances, such as well pad activities and related facilities, are prohibited on slopes 15% and greater and/or side hill cuts of more than 3 feet vertical. Maximum grade on collector and arterial roads is 8% (except pitch grades not exceeding 300 feet in length and 10% in grade). **PURPOSE:** To maintain soil productivity, provide necessary protection to prevent excessive soil erosion on steep slopes, and to avoid areas subject to slope failure, mass wasting, piping, and/or having excessive reclamation challenges **WAIVER:** This condition may be waived by the BLM Authorized Officer if it is determined that the affected area does not include slopes 15% and greater. The burden of providing information to support this determination would be borne by the lessee. **EXCEPTION:** The BLM Authorized Officer may grant an exception to this condition for short distances (less than 300 feet and 10% in grade) for access roads, if the operator submits a certified engineering and reclamation plan that clearly demonstrates impacts from the proposed actions are acceptable or can be adequately mitigated. This plan must include and demonstrate how the following would be accomplished: • Restoration of site • Adequate control of surface runoff. • Protection of the site and adjacent areas from accelerated erosion, such as drilling, gullying, piping, and slope failure and mass wasting • Protection of nearby water sources from sedimentation; water quality and quantity would be in conformance with state and federal water quality standards • Completion of site-specific analysis of soil physical, chemical, and mechanical (engineering) properties and behavior • Timing of surface-disturbing activities, which would not be conducted during extended wet periods • Timing of reclamation, which would not be allowed when soils are frozen In addition, the operator must provide an evaluation of past practices on similar terrain and be able to demonstrate success under similar conditions.	✓				

<table>
<tr><th rowspan="2">Stipulation Number (Existing/New) Protected Resource Acres Affected[1]</th><th rowspan="2">Stipulation Description</th><th colspan="5">Alternative</th></tr>
<tr><th>No Action</th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td></td><td>MODIFICATION: The area affected by this condition may be modified by the BLM Authorized Officer if it is determined that portions of the area do not include slopes of 15% and greater. The burden of providing information to support this determination would be borne by the lessee.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CSU-6
Steep Slopes, Benches, and Soils
BLM surface/federal fluid minerals: 673,900 acres
Non-BLM surface/federal fluid minerals: 192,200 acres</td><td>Surface occupancy or use on slopes of 15% and greater and/or side hill cuts of more than 3 feet vertical; sensitive soils, such as Badland soils and biological soil crust communities; and pristine benches (exposed sandstone mesas) is subject to the following requirement: Surface disturbances on all slopes of 15% and greater, pristine benches (exposed sandstone mesas), and areas with sensitive soils (e.g. Badland soils and biological soil crust communities) are to be avoided.

If surface disturbance cannot be avoided within areas with sensitive soils or pristine benches where slopes are less than 15%, disturbance should be mitigated and would be subject to requirements, including but not limited to, the following:
• Utilize existing disturbance and corridors
• Twin and/or collocate wells
• Implement a fully developed BMP erosion control strategy
• Conduct routine checks and maintenance of erosion control strategy
• Do not construct during times at which the soil is frozen or wet
• Utilize closed-loop systems only (no open pits)
• Develop and implement a spill prevention and leak detection plan and use appropriate equipment (leak detection and automatic shutoff system) for all wells, facilities, and pipelines

PURPOSE: To reduce the impacts of surface disturbance on soil erosion, soil productivity, slope failure, mass wasting, and excessive reclamation challenges within sensitive soils and on steep slopes, and to minimize wildlife habitat disturbance within the pristine benches

WAIVER: None

EXCEPTION: An exception may be granted on a case-by-case basis in the following circumstances:
• Within pristine benches:
– If all access roads are gated and locked, with limited/administrative access only
– If the lessee provides a POD demonstrating that fragmentation and disturbance would be sufficiently limited and minimized, as determined by the BLM Authorized Officer</td><td></td><td>✓</td><td>✓</td><td></td><td></td></tr>
</table>

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
	• Within sensitive soils: – If the lessee provides a POD demonstrating that operations can be conducted without adversely affecting the protected resources **MODIFICATION:** A modification may be granted by the BLM Authorized Officer if the lessee can demonstrate that portions of the area do not include slopes 15% and greater and/or sensitive soils.					
CSU-7 *Steep Slopes, Benches, and Soils* BLM surface/federal fluid minerals: 673,900 acres Non-BLM surface/federal fluid minerals: 192,200 acres	Surface occupancy or use on slopes 15% and greater and/or side hill cuts of more than 3 feet vertical; sensitive soils, such as Badland soils and biological soil crust communities; fragile soils; and pristine benches (exposed sandstone mesas) is subject to the following requirements: • Avoid surface disturbances on all slopes of 15% and greater, pristine benches (exposed sandstone mesas), and areas with sensitive/fragile soils (e.g. Badland soils and biological soil crust communities) If surface disturbance cannot be avoided within areas with fragile/sensitive soils or pristine benches where slopes are less than 15%, disturbance should be mitigated and would be subject to requirements, including but not limited to, the following: • Utilize existing disturbance and corridors • Twin and/or collocate wells • Implement a fully developed BMP erosion control strategy • Conduct routine checks and maintenance of erosion control strategy • Do not construct during times at which the soil is frozen or wet • Utilize closed-loop systems only (no open pits) • Develop and implement a spill prevention and leak detection plan and appropriate equipment (leak detection and automatic shutoff system) for all wells, facilities, and pipelines **PURPOSE:** To reduce the impacts of surface disturbance on soil erosion, soil productivity, slope failure, mass wasting and excessive reclamation challenges within fragile/sensitive soils and on steep slopes, and to minimize wildlife habitat disturbance within the pristine benches **WAIVER:** None				✓	✓

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
	EXCEPTION: An exception may be granted on a case-by-case basis in the following circumstances: • Within pristine benches: – If all access roads are gated and locked, with limited/administrative access only – If the lessee provides a POD demonstrating fragmentation and disturbance would be sufficiently limited and minimized, as determined by the BLM Authorized Officer • Within fragile/sensitive soils: – If the lessee provides a POD demonstrating that operations can be conducted without adversely affecting the protected resources. **MODIFICATION:** A modification may be granted by the BLM Authorized Officer if the lessee can demonstrate that portions of the area do not include slopes of 15% and greater and/or sensitive/fragile soils.					
Water Resources						
CSU-8 *Domestic wells* BLM surface/federal fluid minerals: 5,300 acres Non-BLM surface/federal fluid minerals: 20,200 acres	Surface occupancy or use within 1,000 feet of all domestic water wells or community water sources is subject to, but not limited to, the following requirement: Operator must submit a plan of development demonstrating that operations can be conducted without adversely affecting the protected resources. Examples of actions that could be used to demonstrate protection include, but are not limited to, closed-loop systems and a minimum casing length requirement of 500 feet. **PURPOSE:** To reduce the likelihood of drinking water contamination **WAIVER:** None **EXCEPTION:** An exception to the setback portion of this stipulation may be granted on a case-by-case basis, when engineering and best available science have demonstrated that the same amount of protection can be applied with a lesser buffer or if the operator can show that operations can be conducted without adversely affecting the protected resources. Examples of actions that could be used to demonstrate protection include, but are not limited to, closed-loop systems. **MODIFICATION:** None			✓		

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
	Vegetation Resources					
CSU-9 *100-year Floodplain* BLM surface/federal fluid minerals: 41,800 acres Non-BLM surface/federal fluid minerals: 34,000 acres	Controlled surface use requiring special mitigation measures to stabilize channels, in order to prevent migration of channel onto well sites may be required within the 100-year floodplain. Special mitigation measures to stabilize channels in order to prevent migration of the channel onto well sites may be required within the 100-year floodplain. **PURPOSE:** To reduce the likelihood of migration of channels for the protection of cultural, wildlife, and other critical resources; any portion of a lease area that contains these special values would require special attention to prevent damage to surface resources. Any surface use or occupancy within such areas would be strictly controlled. Use or occupancy would be authorized only when the lessee/operator demonstrates that the area is essential for operations and when the lessee/operator submits a surface use and operations plan, which is satisfactory to the federal surface management agency, for the protection of these special values and existing or planned uses. After the federal surface management agency has been advised of this proposed surface use or occupancy of these lands, and on request of the lessee/operator, the federal surface management agency would furnish further data on such areas. Any changes to this stipulation would be made in accordance with the land use plan and/or the regulatory provisions for such changes. **WAIVER:** None **EXCEPTION:** None **MODIFICATION:** None	✓				

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative: No Action	Alternative: A	Alternative: B	Alternative: C	Alternative: D
CSU-10 *Ephemeral Wash Areas and Wetlands* BLM surface/federal fluid minerals: 524,000 acres Non-BLM surface/federal fluid minerals: 268,900 acres	Surface use or occupancy is restricted within up to 500 feet from the outside edge of the NSO around the riparian system, including the Ephemeral Wash Riparian Area, and known and newly discovered wetlands and natural seeps/springs to protect riparian systems, given channel migration, and to facilitate attainment and maintenance of PFC in the 100-year floodplain. Where surface occupancy or use is authorized, it is subject to, but not limited to, the following constraints: • Avoid placing roads or pipelines in or through banks and channels • Develop a spill prevention and leak detection plan and use appropriate equipment (leak detection and automatic shutoff system) on all wells, facilities, and pipelines • Use a closed-loop system for drilling • Ensure a minimum casing length of 500 feet • Use a fully developed BMP erosion control strategy, including routine checks and maintenance of said erosion control strategy • Construct sediment barrier fences to BLM specifications in designated riparian area active channels that may be destabilized due to construction or as off-site mitigation to protect the integrity of designated riparian areas **PURPOSE:** To maintain healthy and sustainable riparian areas, maintain PFC within the 100-year floodplain, and reduce water channel migration, which can erode soil and riparian vegetation **WAIVER:** None **EXCEPTION:** An exception may be granted on a case-by-case basis from the erosion control plan requirement if proof of channel stabilization is provided and is determined by the BLM Authorized Officer to be an acceptable alternative. Additionally, an exception may be granted for access roads branching off an existing road, if such road is determined by the BLM Authorized Officer to pose no threat to soil or channel integrity. **MODIFICATION:** None			✓		

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
	Special Status Species					
CSU-11 *Gunnison's prairie dog colony* BLM surface/federal fluid minerals: 4,300 acres Non-BLM surface/federal fluid minerals: 300 acres	Surface occupancy or use within 165 feet (50 meters) of active Gunnison's prairie dog colony boundaries is subject to the following operational constraint: Proposed projects would be relocated outside the restriction zone around the colony, or they would be moved to use existing surface disturbance, as determined at the time of the proposed action. **PURPOSE:** To comply with federal and state requirements for protection of threatened and endangered species and their habitat, as well as to protect the habitat of sensitive, non-listed species to prevent the need for listing them as threatened or endangered **WAIVER:** This stipulation may be waived if, after consulting with the New Mexico Department of Game and Fish and the BLM Wildlife Biologist State Office Program Lead, it is determined that the described lands are no longer occupied by prairie dogs and thus do not warrant consideration for protection. **EXCEPTION:** An exception to this condition may be granted by the BLM Authorized Officer on a case-by-case basis for pipelines that may be planned through the colony. Additionally, an exception may be granted if the lessee submits a POD, which demonstrates that the impacts from the proposed action can be adequately mitigated without re-siting. The burden of providing information to support this determination would be borne by the lessee. Finally, an exception may be granted if there are no burrowing owl nests at the edge of the colony where the disturbance is proposed. **MODIFICATION:** A modification allowing surface-disturbing activities within the colony may be granted if the BLM Authorized Officer determines that portions of the area can be occupied without adversely affecting prairie dogs.		✓	✓		

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
CSU-12 *Gunnison's prairie dog colony* BLM surface/federal fluid minerals: 3,500 acres Non-BLM surface/federal fluid minerals: 200 acres	Surface occupancy or use within the boundary of active Gunnison's prairie dog colonies is subject to the following operational constraint: Proposed projects would be relocated outside the colony or to the edge of the colony, or they would be moved to use existing surface disturbance, as determined at the time of the proposed action. **PURPOSE:** To comply with federal and state requirements for protection of threatened and endangered species and their habitat, as well as to protect the habitat of sensitive, non-listed species to prevent the need for listing them as threatened or endangered **WAIVER:** This stipulation may be waived if, after consulting with the New Mexico Department of Game and Fish, and the BLM Wildlife Biologist State Office Program Lead, it is determined that the described lands are no longer occupied by prairie dogs and thus do not warrant consideration for protection. **EXCEPTION:** An exception to this condition may be granted by the BLM Authorized Officer on a case-by-case basis for pipelines that may be planned through the colony. Additionally, an exception may be granted if the lessee submits a POD that demonstrates that the impacts from the proposed action can be adequately mitigated without re-siting. The burden of providing information to support this determination would be borne by the lessee. Finally, an exception may be granted if there are no burrowing owl nests at the edge of the colony where the disturbance is proposed. **MODIFICATION:** A modification allowing surface-disturbing activities within the colony may be granted if the BLM Authorized Officer determines that portions of the area can be occupied without adversely affecting prairie dogs.				✓	✓

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative: No Action	A	B	C	D
CSU-13 *Clover's cactus and Aztec gilia habitat* BLM surface/federal fluid minerals: 250,400 acres Non-BLM surface/federal fluid minerals: 38,500 acres	For proposed projects within Clover's cactus and Aztec gilia habitat, a biological survey would be required. When individual plants or suitable habitat for these plants are found within designated potential habitat during a biological survey for a proposed project, every effort to relocate the proposed project would be explored to minimize disturbance. If proposed project activities are not initiated within 1 year of a biological survey, a new survey may be needed, depending on the location of the project area. A new biological survey would be determined by a BLM/FFO biologist on a case-by-case basis. **PURPOSE:** To reduce impacts on Clover's cactus and Aztec gilia habitat for the protection of cultural, wildlife, and other critical resources. Any portion of a lease area that contains these special values would require special attention to prevent damage to surface resources. Any surface use or occupancy within such areas would be strictly controlled. Use or occupancy would be authorized only when the lessee/operator demonstrates that the area is essential for operations and when the lessee/operator submits a surface use and operations plan, which is satisfactory to the federal surface management agency, for the protection of these special values and existing or planned uses. After the federal surface management agency has been advised of this proposed surface use or occupancy of these lands, and on request of the lessee/operator, the federal surface management agency would furnish data on such areas. Any changes to this stipulation would be made in accordance with the land use plan and/or the regulatory provisions for such changes. **WAIVER:** None **EXCEPTION**: None **MODIFICATION**: None	✓				

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
CSU-14 *Protection of Special Status Plant Species* BLM surface/federal fluid minerals: 250,400 acres Non-BLM surface/federal fluid minerals: 38,500 acres	The lease contains potential, suitable and/or occupied habitat for special status plant species; therefore, special status plant species clearance surveys are required to be completed prior to any surface-disturbing activities being approved within or adjacent to BLM special status plant species' potential, suitable, and/or occupied habitats. If proposed project activities do not begin within 1 year of a biological survey, a new survey may be needed, depending on the location of the project area. The need for a new biological survey would be determined by the BLM Authorized Officer on a case-by-case basis. Survey requirements include the following: • Clearance surveys must be conducted by a qualified botanist. • The area to be surveyed would include at a minimum the project area plus an additional 328 feet (100) meters outside the project area. • Clearance surveys would be conducted during the blooming season or the period in which the plant species is most easily detected, as determined by the BLM. Based on the results of the survey, if special status plant species are identified within the project boundary and in the area of indirect/direct impacts or affected habitat, the following operational constraints would be required in occupied or mapped suitable habitat: • Avoidance/restriction of development, such as locating the surface disturbance area away from the edge of occupied or suitable habitat and ideally outside the area where indirect/direct impacts would occur (the area of avoidance could be a minimum of 164 feet (50 meters) but possibly greater than 656 feet (200 meters), as determined by the BLM). • Minimize the area of disturbance, using such strategies as, but not limited to, twinning, and using existing disturbance and corridors. Additional operational constraints may be required and could include, but are not limited to, any of the following: • Dust abatement measures • Signs, fencing, and other deterrents to reduce possible human disturbance • Construction of well sites, roads, and associated facilities (including projects within 328 feet (100 meters) of occupied habitat) outside the blooming season • Specialized reclamation procedures such as, but not limited to, – Separating soil and subsoil layers with barriers to reclaim in the correct order		✓			

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
	– Using a higher percentage of forbs in the reclamation seed mix to promote pollinator habitat – Collecting seeds for sensitive plant species' genetic preservation, grow-out, and reclamation • Long-term monitoring of indirect/direct impacts on the species and/or habitat • Qualified, independent third-party contractors to provide general oversight and ensure compliance with project terms and conditions during construction • Nonnative or invasive species monitoring and control in occupied and suitable habitat **PURPOSE:** To conserve BLM special status species and the ecosystems upon which they depend by minimizing direct and indirect impacts, including loss of habitat and impacts on important pollinators and their habitat, as a result of dust transport, weed invasion, and chemical and produced water spills (USDI-BLM Manual 6840 - Special Status Species Management) **WAIVER:** If the species is delisted and removed from the BLM State Director's Sensitive Species List, a waiver may be granted by the BLM Authorized Officer. **EXCEPTION**: An exception to the avoidance/restriction and/or minimization operational constraints may be granted by the BLM Authorized Officer if the lessee can demonstrate and the NEPA analysis determines that the proposed project would not cause adverse impacts or have negligible impacts on occupied and suitable habitat. This could include situations where, based on the results of the clearance survey, it is determined that the project area contains topographical features or natural barriers that sufficiently create a buffer between the surface disturbance and the occupied habitat so that the proposed project can be conducted without adversely affecting the integrity of occupied and/or suitable habitat. In addition, an exception may be granted for maintenance of existing facilities or for new construction disturbances located adjacent to an existing disturbance, if an environmental analysis of the proposed action indicates that the activity could be conditioned so as to result in a much reduced cumulative environmental impact on the species compared to other project alternatives. If an exception is granted, special design, construction, reclamation, and implementation measures, including postponing construction by more than 60 days, may be required. In addition, if an exception is granted and the action results in the removal of special status plants, viable seeds must be collected and properly stored to preserve the genetic materials.					

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
	MODIFICATION: The BLM Authorized Officer may modify (increase, decrease, or relocate) the area subject to the stipulation if it is determined that the nature or conduct of the activity, as proposed or conditioned, would not impair values associated with the maintenance or recovery of the species. In addition, if portions of the lease have been determined to be unoccupied by the species for a minimum period of 20 years, then the habitat would no longer be considered occupied and/or suitable habitat and a modification may be granted by the BLM Authorized Officer. Due to the persistence of the seed bank and variability in environmental conditions related to germination, this determination requires surveys to be performed over multiple years.					
CSU-15 *Special status plant species* BLM surface/federal fluid minerals: 250,400 acres Non-BLM surface/federal fluid minerals: 38,500 acres	For proposed projects in and adjacent to potential, suitable, and/or occupied habitat for special status plant species habitat, a biological survey would be required. When individual plants or suitable habitat for these plants are found within designated potential habitat during a biological survey for a proposed project, every effort to relocate the proposed project would be explored to minimize impacts. If proposed project activities are not initiated within 1 year of a biological survey, a new survey may be needed, depending on the location of the project area. A new biological survey would be determined by the BLM Authorized Officer on a case-by-case basis. **PURPOSE:** To conserve BLM special status species and the ecosystems upon which they depend by minimizing direct and indirect impacts, including loss of habitat and impacts on important pollinators and their habitat, as a result of dust transport, weed invasion, and chemical and produced water spills (USDI-BLM Manual 6840 - Special Status Species Management) **WAIVER:** If the species is delisted and removed from the BLM State Director's Sensitive Species List, a waiver may be granted by the BLM Authorized Officer. **EXCEPTION**: An exception to the avoidance/restriction and/or minimization operational constraints may be granted by the BLM Authorized Officer, if the lessee can demonstrate and the NEPA analysis determines that the proposed project would not cause adverse impacts or have negligible impacts on occupied and suitable habitat. This could include situations where, based on the results of the clearance survey, it is determined that the project area contains topographical features or natural barriers that sufficiently create a buffer between the surface disturbance and the occupied			✓	✓	✓

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
	habitat so that the proposed project can be conducted without adversely affecting the integrity of the occupied and/or suitable habitat. In addition, an exception may be granted for maintenance of existing facilities or for new construction disturbances located adjacent to an existing disturbance if an environmental analysis of the proposed action indicates that the activity could be conditioned so as to result in a much reduced cumulative environmental impact on the species compared to other project alternatives. If an exception is granted, special design, construction, reclamation, and implementation measures, including postponing construction by more than 60 days, may be required. In addition, if an exception is granted, and the action results in the removal of special status plants, viable seed must be collected and properly stored to preserve the genetic materials. **MODIFICATION**: The BLM Authorized Officer may modify (increase, decrease, or relocate) the area subject to the stipulation, if it is determined that the nature or conduct of the activity, as proposed or conditioned, would not impair values associated with the maintenance or recovery of the species. In addition, if portions of the lease have been determined to be unoccupied by the species for a minimum period of 20 years, then the habitat would no longer be considered occupied and/or suitable habitat and a modification may be granted by the BLM Authorized Officer. Due to the persistence of the seed bank and variability in environmental conditions related to germination, this determination requires surveys to be performed over multiple years.					
CSU-16 *Federally listed species critical habitat* BLM surface/federal fluid minerals: 3,100 acres Non-BLM surface/federal fluid minerals: 1,100 acres	Surface use and occupancy in all designated and proposed critical habitat for federally listed species would be subject to, but not limited to, the following constraints: • Complete the ESA Section 7 consultation with USFWS on threatened or endangered species • Complete the valid current surveys for protected species • Apply mitigation to avoid adverse impacts on protected species • Submit monitoring reports **PURPOSE:** To reduce impacts on critical habitat of listed species **WAIVER**: None **EXCEPTION**: An exception may be granted if the proposed disturbance would occur in unsuitable habitat. Allow occupancy within 656 feet (200 meters) when terrain and topography provide adequate protections. **MODIFICATION**: None				✓	

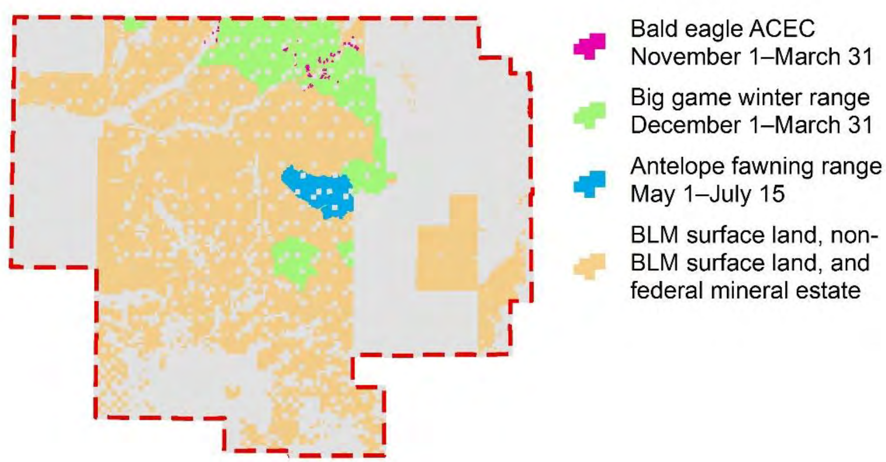
Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
CSU-17 *Special status bat species*	The lease or portions of the lease is known to contain special status bat species habitat. Parcels potentially containing special status bat species maternity roosts or hibernacula within special status bat species habitat shall undergo a site-specific survey by a BLM-approved specialist/biologist to identify necessary special design, construction, implementation, and/or mitigations measures. Based on BLM site-specific survey results, planned surface-disturbing activities may require relocation beyond standard lease terms and conditions (i.e., beyond 656 feet [200 meters]) through application of COAs at the APD stage. If the BLM's site-specific survey results reveal the existence of special status bat species maternity roosts or hibernacula within USFWS confirmed habitat and appropriate surface-disturbing activity relocation is unattainable, additional protective/mitigation measures may be required of the lessee and/or operator, to include, but not limited to, the following: • Development and implementation of a BLM-approved mitigation/protection plan for activities known to cause adverse impacts to special status bat species maternity roosts or hibernacula within special status bat species habitat. This plan may require, but is not limited to, special design, construction, and implementation measures describing how adverse impacts to known special status bat species maternity roosts or hibernacula special status bat species habitat would be prevented or mitigated. • Disturbance area minimization; use of previously existing disturbed areas, roads, well-pads, and corridors; and implementation of mitigation measures such as operational twinning. **PURPOSE:** To prevent disturbance or destruction of known special status bat species roosts, hibernacula, or special status bat species habitat. **WAIVER**: None **EXCEPTION**: The BLM authorized officer may provide for site-specific exception(s) if the operator/lessee's operation plan provides appropriate levels of protective special design, construction, and implementation measures to prevent additional species loss. **MODIFICATION**: None		✓	✓	✓	

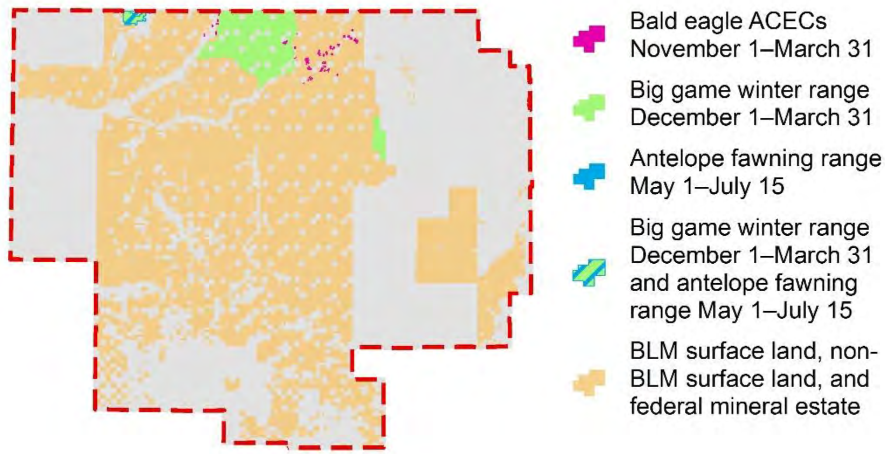
Table D-4
Timing Limitation Stipulations Applicable to Fluid Mineral Leasing

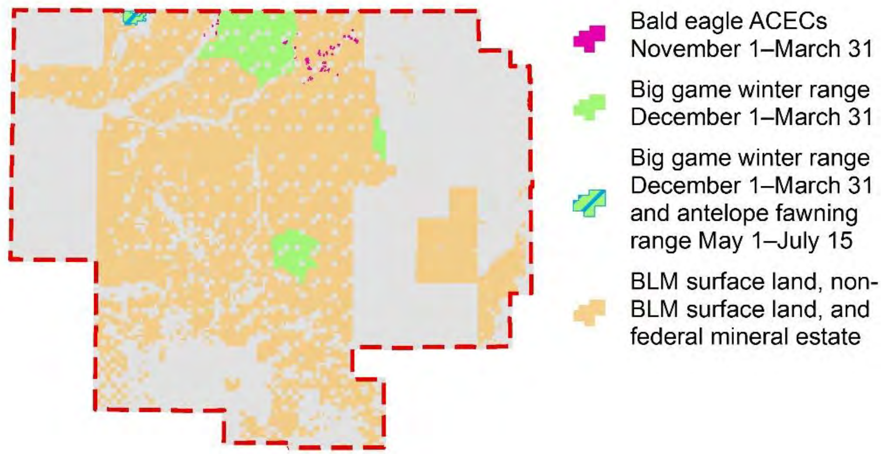
Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
Note: **Figures D-1** through **D-5**, in this table, show the wildlife TLs in SDAs for each alternative. **Figures D-6**, **D-7**, and **D-8**, after this table, show the non-mapped wildlife TLs for each alternative.						
Cultural Resources						
TL-1 *CCNHP Peak Visitation* BLM surface/federal fluid minerals: 13,700 acres Non-BLM surface/federal fluid minerals: 2,600 acres	No construction, drilling, well completions, and/or workover rigs are allowed for 1 mile on either side of the main entrance road into the CCNHP (i.e., County Road 7950) during peak visitation times, from April through October. Additional timing limitations on activities in this area could be identified through Section 106 consultation. **PURPOSE:** To reduce possible impacts of development on cultural, traditional, and religious practices **WAIVER:** None **EXCEPTION:** Exception could apply if actions would not impact dark skies, noise, or VRM or cause increased traffic to compete with tourism/visitation during peak times. Operators would have to demonstrate the ability to eliminate impacts and concerns, which may include advanced use of new technology and consultation with the CCNHP. **MODIFICATION:** None			✓		
Fish and Wildlife						
TL-2 *Wildlife SDAs* No Action Alternative: BLM surface/federal fluid minerals: 268,100 acres Non-BLM surface/federal fluid minerals: 60,300 acres	Surface construction, drilling, workover, or completion activities, surface occupancy, or use is not allowed on lands within important seasonal wildlife habitat. This stipulation does not apply to operation and maintenance of production facilities. **PURPOSE:** For the protection of wildlife habitat during key seasonal periods, such as fawning, calving, wintering, and nesting in order to sustain populations **WAIVER:** None **EXCEPTION:** Exceptions may be granted on a case-by-case basis as determined by the BLM Authorized Officer and would be determined by taking into account the such	✓	✓	✓	✓	✓

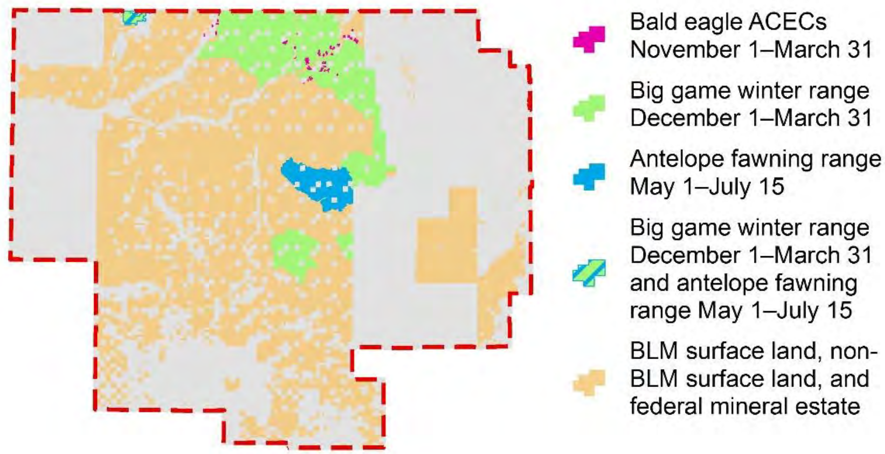
Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
Alternative A: BLM surface/federal fluid minerals: 103,200 acres Non-BLM surface/federal fluid minerals: 13,900 acres Alternative B: BLM surface/federal fluid minerals: 151,100 acres Non-BLM surface/federal fluid minerals: 16,600 acres Alternative C: BLM surface/federal fluid minerals: 268,100 acres Non-BLM surface/federal fluid minerals: 60,300 acres Alternative D: BLM surface/federal fluid minerals: 6,800 acres	criteria as animal density, severity of the winter, length of the proposed operations, condition of the surrounding habitat, and amount of existing disturbance. Cavitation of wells, unless an emergency need exists to restore a dramatic loss in volume or a nonfunctional well, would be considered non-routine, and an exception to the seasonal restrictions would be considered on a case-by-case basis. No exceptions would be granted north of La Jara Wash within the Rosa Mesa Wildlife Area. **MODIFICATION:** None See **Chapter 2**, **Table 2-3**, TL for Wildlife, for specific areas that would be subject to this stipulation.					

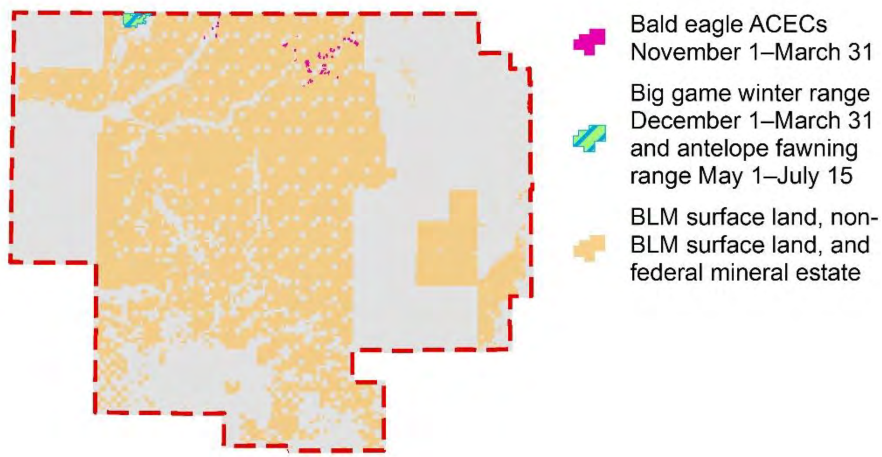
Figure D-1
Wildlife TLs in SDAs—No Action Alternative



Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
Non-BLM surface/federal fluid minerals: 3,100 acres	**Figure D-2** **Wildlife TLs in SDAs—Alternative A** 					

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
	Figure D-3 **Wildlife TLs in SDAs—Alternative B** 					

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
	Figure D-4 **Wildlife TLs in SDAs—Alternative C** 					

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
	Figure D-5 **Wildlife TLs in SDAs—Alternative D** 					
TL-3 *Migratory Birds*	For proposed projects 4.0 acres or more of surface disturbance, no construction activities from May 15 to July 31 would be permitted without a migratory bird nest survey. These surveys would be conducted by a BLM/FFO–Authorized Officer using a survey protocol provided by a BLM/FFO approved biologist. If any active nests are located within the proposed project area, construction activities would not be allowed until written consent is received from a BLM/FFO Authorized Officer. If construction is allowed when the nests identified in the survey are still active, the BLM may be require monitoring, and construction may be required to stop if it is determined to be disrupting the nest. **PURPOSE:** Minimize and avoid impacts on nesting migratory birds **WAIVER:** None		✓	✓	✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
	EXCEPTION: Exceptions may be granted by the BLM Authorized Officer, if it is determined that proposed actions would not significantly impact migratory birds and their habitat or if the NEPA document adequately discloses impacts on nesting birds. **MODIFICATION:** None					
Special Status Species						
F-1 TL *Seasonal Raptor Nesting Habitat*	F1 Timing Limitation Stipulation—Important Seasonal Raptor Nesting Habitat • Ferruginous hawk: No surface use is allowed from March 1 to June 30 within 0.33 miles of an active or historical nest, for the protection of important seasonal wildlife habitat (bird of prey nests). This stipulation may apply to operation and maintenance of production facilities, if it is determined that the operation and/or maintenance activity negatively impacts the nesting behavior of the raptor. Exceptions may apply, depending on the level of disturbance and nesting chronology of a breeding pair. • Prairie falcon: No surface use is allowed from March 1 to June 30 within 0.33 miles of an active or historical nest, for the protection of important seasonal wildlife habitat (bird of prey nests). This stipulation may apply to operation and maintenance of production facilities, if it is determined that the operation and/or maintenance activity negatively impacts the nesting behavior of the raptor. Exceptions may apply, depending on the level of disturbance and nesting chronology of the breeding pair. • Peregrine falcon: No surface use is allowed from March 1 to June 30 within 0.33 miles of an active or historic nest, for the protection of important seasonal wildlife habitat (bird of prey nests). This stipulation may apply to operation and maintenance of production facilities, if it is determined that the operation and/or maintenance activity negatively impacts the nesting behavior of the raptor. Exceptions may apply, depending on the level of disturbance and nesting chronology of the breeding pair. **PURPOSE:** For the protection of seasonal wildlife habitat, no surface use is allowed during the period **WAIVER:** None	✓				

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
	EXCEPTION: This stipulation does not apply to operation and maintenance of production facilities. **MODIFICATION:** None					
TL-4 *Raptor Nest Sites*	Surface construction, drilling, workover, or completion activities, surface occupancy, or use is not allowed during seasonal raptor nesting periods. Raptor nesting sites, both active and historical, will be avoided by the distances and seasonal periods listed below. This stipulation does not apply to operation and maintenance of production facilities except for when operation and maintenance of wells, production, and associated facilities are determined to have a negative impact on the nesting behavior of the raptors. • Ferruginous hawk—0.33 miles (March 1 to June 30) • Prairie falcon—0.33 miles (March 1 to June 30) • Peregrine falcon—0.33 miles (March 1 to June 30) • Osprey—0.25 miles (during the nesting/rearing stage, April 1 to August 31) Noise from oil and gas equipment that operates continuously (more than 8 hours/day on a long-term basis, which is more than 1 week in duration) would be kept at or below 48.6 dBA at specified locations. This would be done to minimize disturbances to raptor nest sites for ferruginous hawks and prairie falcons. **PURPOSE:** Protection of important seasonal wildlife habitat (bird of prey nests) **WAIVER:** None **EXCEPTION:** Exceptions may be granted on a case-by-case basis for nests that have been deemed inactive for the season, as determined via survey by the BLM biologist. The exception would also depend on the level of disturbance and nesting chronology of the breeding pair. For instance, an exception may be granted once the BLM Authorized Officer determines that the young of the year have fledged and left the area or that the proposed action would not impact the nesting activities of the raptor. **MODIFICATION:** None		✓	✓	✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
F1 *Golden Eagle Nest Sites*	F1 Timing Limitation Stipulation—Important seasonal raptor nesting habitat Golden eagles: No surface use is allowed from February 1 to June 30 within 0.5 miles of raptor nest sites for the protection of important seasonal wildlife habitat (bird of prey nests). This stipulation may apply to operation and maintenance of production facilities if determined that the operation and/or maintenance activity negatively impacts the nesting behavior of the raptor. Exceptions may apply, depending on the level of disturbance and nesting chronology of the breeding pair. No construction, drilling, or completion activities shall be conducted from February 1 to June 30 in a radius of 0.5 miles around active and historical golden eagle nest sites. **PURPOSE:** For the protection of seasonal wildlife habitat, no surface use is allowed during the period. **WAIVER:** None **EXCEPTION:** This stipulation does not apply to operation and maintenance of production facilities. **MODIFICATION**: None	✓				

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
TL-5 *Golden and Bald Eagle Nest Sites*	No construction, drilling, completion, or workover activities are allowed from January 1 to June 30 within 0.5 miles of golden and bald eagle nest sites. Additional requirements may apply, depending on project type and impacts on nesting eagles. This stipulation may apply to operation and maintenance of production facilities, if determined that the operation and/or maintenance activity negatively impacts the nesting behavior of the raptor. **PURPOSE:** For the protection of seasonal wildlife habitat, no surface use is allowed during the period. **WAIVER:** None **EXCEPTION:** This stipulation does not apply to operation and maintenance of production facilities. An exception could be authorized by the BLM Authorized Officer, depending on the status of the nest site or the geographical relationship of topographic barriers and vegetation screening to the nest site. **MODIFICATION**: None		✓			
TL-6 *Golden and Bald Eagle Nest Sites*	No construction, drilling, completion, or workover activities are allowed from January 1 to June 30 within 0.5 miles of golden and bald eagle nest sites. Surface-disturbing activities occurring outside of the breeding season (seasonal restriction zone), but within the spatial restriction zone, would be allowed, as long as the activity would not cause the nest site to become unsuitable for future nesting, as determined by BLM/FFO authorized officer. Facilities and other permanent structures would be allowed if they meet the above criteria. This stipulation does not apply to operation and maintenance of production facilities. Courtship/nest building and egg laying/incubation stage: No construction, drilling, or completion activities shall be within 0.5 miles of an active or historical nest during the courtship/nest building and egg laying/incubation stage, from January 1 to March 30. The 0.5-mile restriction zone would mostly pertain to oil and gas drilling operations. Nestling/rearing stage: No construction, drilling, workover, or completion activities shall be within 0.33 miles of an active or historical nest from April 1 to June 30.			✓	✓	✓

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
	Noise from oil and gas equipment that operates continuously (more than 8 hours/day on a long-term basis, which is more than 1 week in duration) would be kept at or below 48.6 dBA, as measured from the nest, to minimize disturbances to golden and bald eagle nest sites. If after the environmental analysis, it is determined that stricter noise standards are necessary, then the BLM may work with the operator on a case-by-case basis to achieve an acceptable level of noise mitigation. This stipulation does not apply to operation and maintenance of production facilities or emergency situations. **PURPOSE:** For the protection of golden and bald eagle nesting habitat **WAIVER:** A waiver may be granted if a nest has been determined to be inactive, generally after 5 years of nonbreeding activity, as determined by the BLM/FFO biologist. A survey may be required to determine whether a nest has become inactive. **EXCEPTION:** Exceptions to these timing restrictions would be considered, based on the type, duration, and impacts (if any) of the project on the nesting eagles. An exception may be considered on a case-by-case basis if the nestlings fledge early or the eagles have become acclimated to resource extraction activities, as determined by the BLM biologist. An exception to install or operate a new compressor in a designated eagle seasonal restriction area that is more than 48.6 dBA at 300 feet from the compressor would be considered by the BLM if it is determined that the noise would not adversely impact the nesting eagles. **MODIFICATION:** A modification to a portion of the lease may be granted if a nest has been determined to be inactive, generally after 5 years of nonbreeding activity, as determined by BLM/FFO biologist. A survey may be required to determine whether a nest has become inactive.					
F-3 TL *Bald Eagle Winter Areas*	F-3 Timing Limitation Stipulation—Bald Eagle Winter Areas: No surface use is allowed from November 1 to March 31 in the Bald Eagle ACEC (37 units, totaling 4,141 acres) for the protection of important seasonal wildlife habitat (restriction zones around bald eagle use areas). Within restriction zones are areas of intensive bald eagle use, such as roost	✓				

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
	sites, where any surface-disturbing activity is prohibited year-round. This stipulation does not apply to operation and maintenance of production facilities. (ROD, B-2). **PURPOSE:** For the protection of seasonal wildlife habitat, no surface use is allowed during the period. **WAIVER:** None **EXCEPTION:** This stipulation does not apply to operation and maintenance of production facilities. **MODIFICATION:** None					
TL-7 *Bald Eagle Winter Areas*	Construction, drilling, completion, or workover activities would be not be allowed November 1 through March 31 in the Bald Eagle ACEC. A year-round noise restriction also applies. Continuous noise sources may not exceed 48.6 dBA, as measured at the boundary of the core areas within the ACEC. If after the environmental analysis, it is determined that stricter noise standards are necessary, then the BLM may work with the operator on a case-by-case basis to achieve an acceptable level of noise mitigation. This stipulation does not apply to operation and maintenance of production facilities or emergency situations. **PURPOSE:** To protect the most important bald eagle wintering habitat and the bald eagles that use these areas throughout the winter **WAIVER:** None **EXCEPTION:** No exceptions would be approved due to the necessity of having to re-consult with the USFWS and the relatively minor amount of area covered by this stipulation. **MODIFICATION:** None		✓	✓	✓	✓

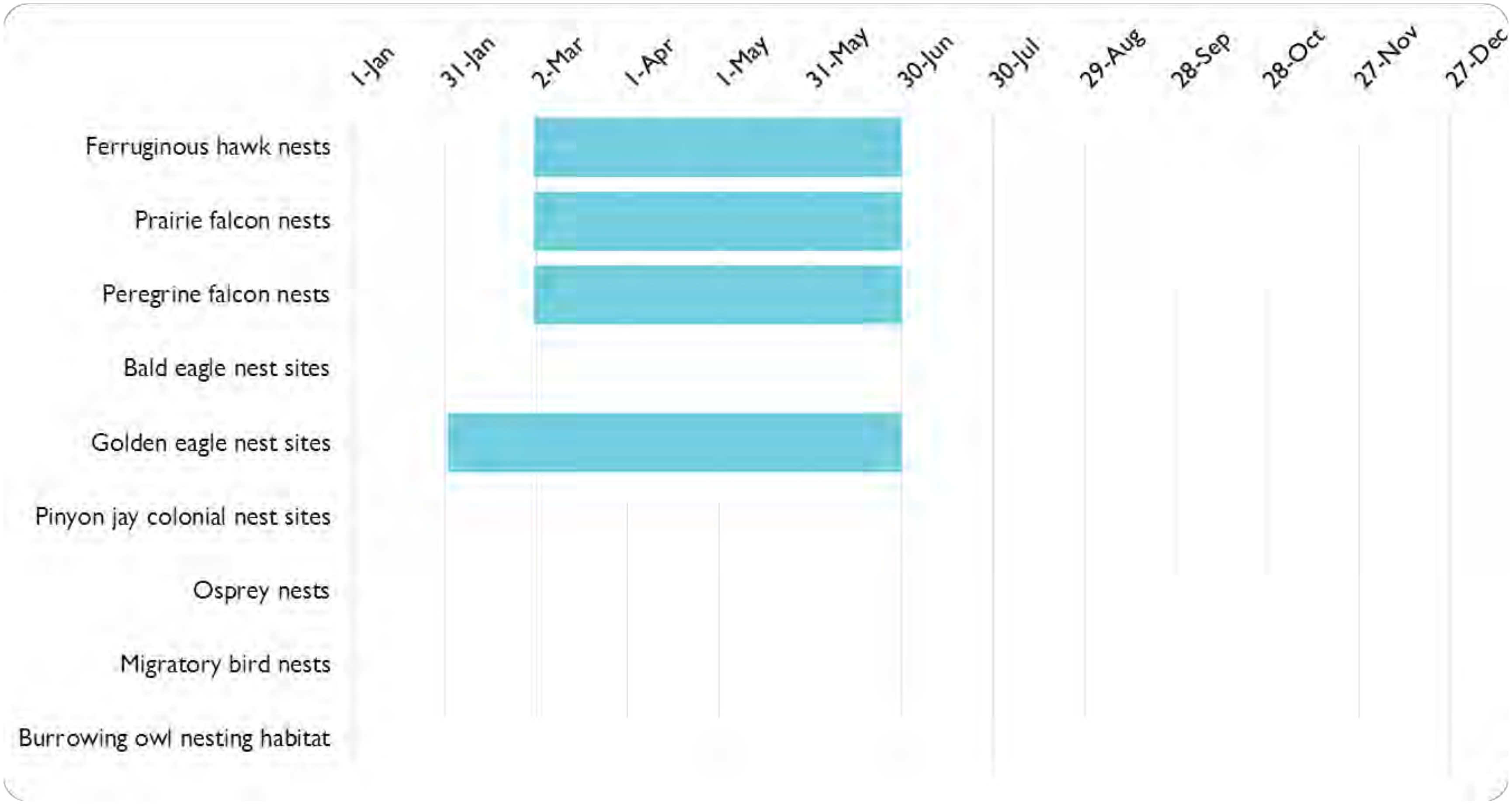
Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
TL-8 *Pinyon Jay Colonial Nest Sites*	Construction, drilling, completion, or workover activities will not be allowed within 3,168 feet (0.6 miles) of an active pinyon jay colonial nest site from March 1 to August 1. Noise levels would not exceed 48.6 dBA at the edge of the active nesting colony. **PURPOSE:** To protect pinyon jay colonial nest sites to reduce the potential for their species listing under the federal ESA. **WAIVER:** None **EXCEPTION:** This stipulation does not apply to operation and maintenance of production facilities. An exception may be granted if the BLM Authorized Officer determines that the young of the year have fledged and left the area, that surveys have conclusively determined the nest is not active, or that the proposed action would not impact the nesting activities. **MODIFICATION:** None		✓	✓		
TL-9 *Pinyon Jay Colonial Nest Sites*	Construction, drilling, completion, or workover activities will not be allowed within 1,640 feet (500 meters) of active pinyon jay colonial nest sites from March 1 to August 1. Noise levels would not exceed 48.6 dBA at the edge of the active nesting colony. **PURPOSE:** To protect pinyon jay colonial nest sites to reduce the potential for their species listing under the federal ESA. **WAIVER:** None **EXCEPTION:** This stipulation does not apply to operation and maintenance of production facilities or emergency situations unless otherwise specified. An exception may be granted if the BLM Authorized Officer determines that the young of the year have fledged and left the area, that surveys have conclusively determined the nest is not active, or that the proposed action would not impact the nesting activities. **MODIFICATION:** None				✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
TL-10 *Pinyon Jay Colonial Nest Sites*	Construction, drilling, completion, or workover activities will not be allowed within an active pinyon jay colonial nest site from March 1 to August 1. Noise levels would not exceed 48.6 dBA at the edge of the active nesting colony. **PURPOSE:** To protect pinyon jay colonial nest sites to reduce the potential for their species listing under the federal ESA **WAIVER:** None **EXCEPTION:** This stipulation does not apply to operation and maintenance of production facilities or emergency situations unless otherwise specified. An exception may be granted if the BLM Authorized Officer determines that the young of the year have fledged and left the area, that surveys have conclusively determined the nest is not active, or that the proposed action would not impact the nesting activities. **MODIFICATION:** None					✓
TL-11 *Burrowing Owl Nesting Habitat*	A survey for burrowing owls is required for proposed project activity within designated potential nesting habitat from April 1 to August 15. Occupied burrowing owl nests would not be disturbed within a 165-foot radius from April 1 to August 15. This stipulation does not apply to operation and maintenance of production facilities. **PURPOSE:** Protection of burrowing owl potential and occupied nesting habitat **WAIVER:** None **EXCEPTION:** After August 15, any project that would cause destruction of the nest burrow could begin only after confirmation by the BLM that the nest burrow is no longer occupied. **MODIFICATION:** None		✓	✓	✓	

Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative				
		No Action	A	B	C	D
TL-12 *Special Status Plant Species*	No surface construction or ground disturbance is allowed within 330 feet of suitable BLM special status plant species habitat during periods when the species is most sensitive, such as during blooming and fruiting/seeding periods. This stipulation does not apply to operation and maintenance of facilities. **PURPOSE:** To conserve BLM special status species and the ecosystems upon which they depend by minimizing direct and indirect impacts, including interference with reproduction and loss of habitat and impacts on important pollinators and their habitat that result from dust transport, weed invasion, and chemical and produced-water spills during critical reproductive periods (USDI-BLM Manual 6840—Special Status Species Management). Any changes to this stipulation would be made in accordance with the land use plan and/or the regulatory provisions for such changes. (For guidance on the use of this stipulation, see Bureau of Land Management Manuals 1624 and 3101 or Forest Service Manuals 1950 and 2820.) In accordance with the provisions of 43 CFR, Subpart 3101.1-4, if circumstances or relative resource values change or if the lessee demonstrates that operations can be conducted without causing unacceptable impacts, this stipulation may be waived, excepted, or modified by the BLM Authorized Officer if such action is consistent with the provisions of the applicable land use plan or, if not consistent, through a planning amendment. **WAIVER:** A waiver may be granted by the BLM Authorized Officer if the species is delisted and removed from the BLM State Director's sensitive species list. In addition, if portions of the lease have been determined to be unoccupied by the species for a minimum period of 20 years, then the habitat would no longer be considered suitable habitat and a waiver may be granted by the BLM Authorized Officer. Due to the persistence of the seed bank and variability in environmental conditions related to germination, this determination requires surveys to be performed over multiple years. **EXCEPTION:** If the lessee can demonstrate and the NEPA analysis determines that the project would not cause adverse direct or indirect impacts on special status plant species		✓			

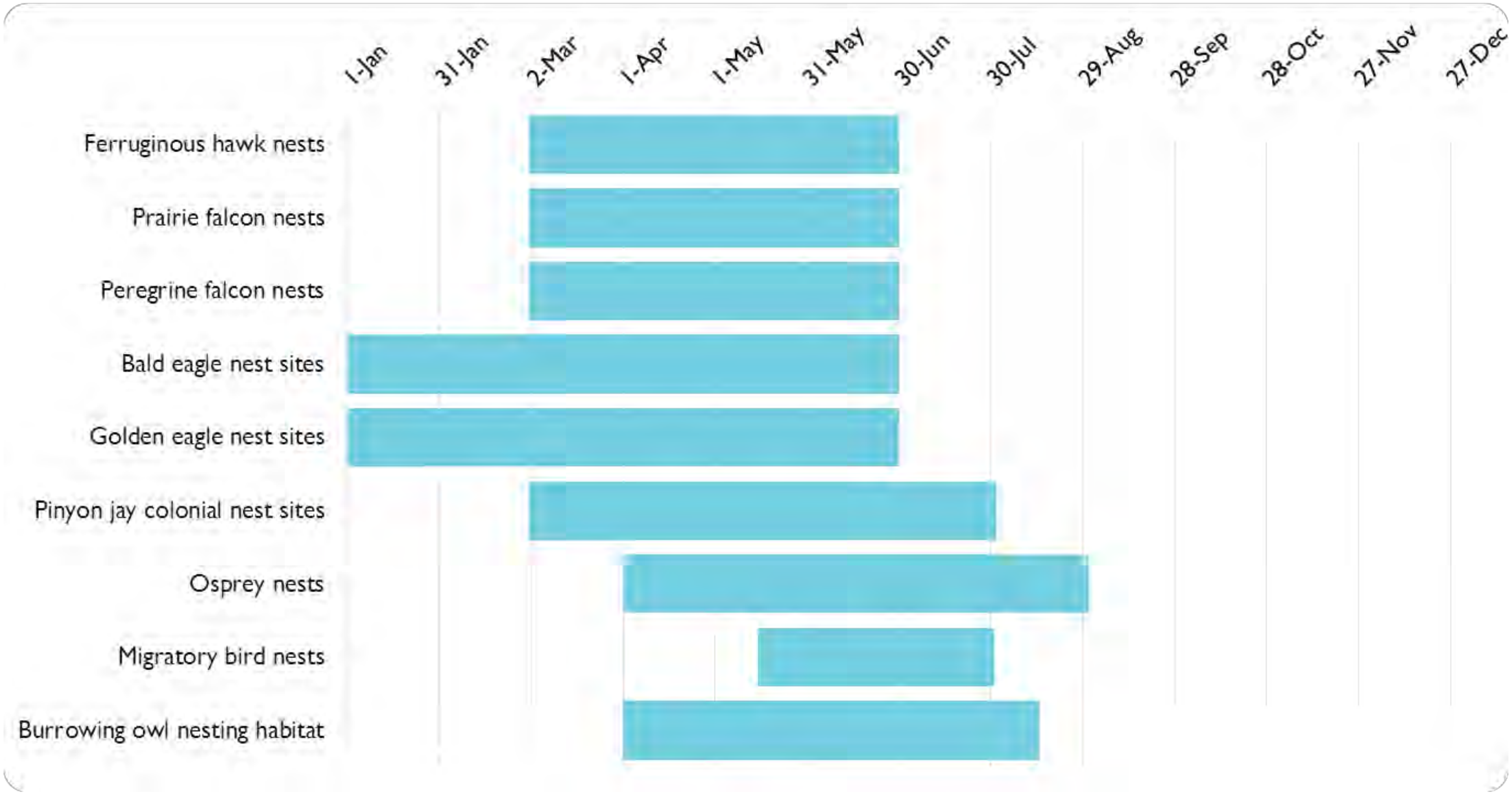
Stipulation Number (Existing/New) Protected Resource Acres Affected[1]	Stipulation Description	Alternative No Action	A	B	C	D
	and habitat to warrant this timing limitation, then an exception may be granted by the BLM Authorized Officer. **MODIFICATION:** The BLM Authorized Officer may modify (increase, decrease, or relocate) the area subject to the stipulation if it is determined that portions of the lease no longer contain suitable habitat. Due to the persistence of the seed bank and variability in environmental conditions related to germination, this determination requires surveys to be performed over multiple years.					

Figure D-6
Unmapped Wildlife TLs—No Action Alternative[1]



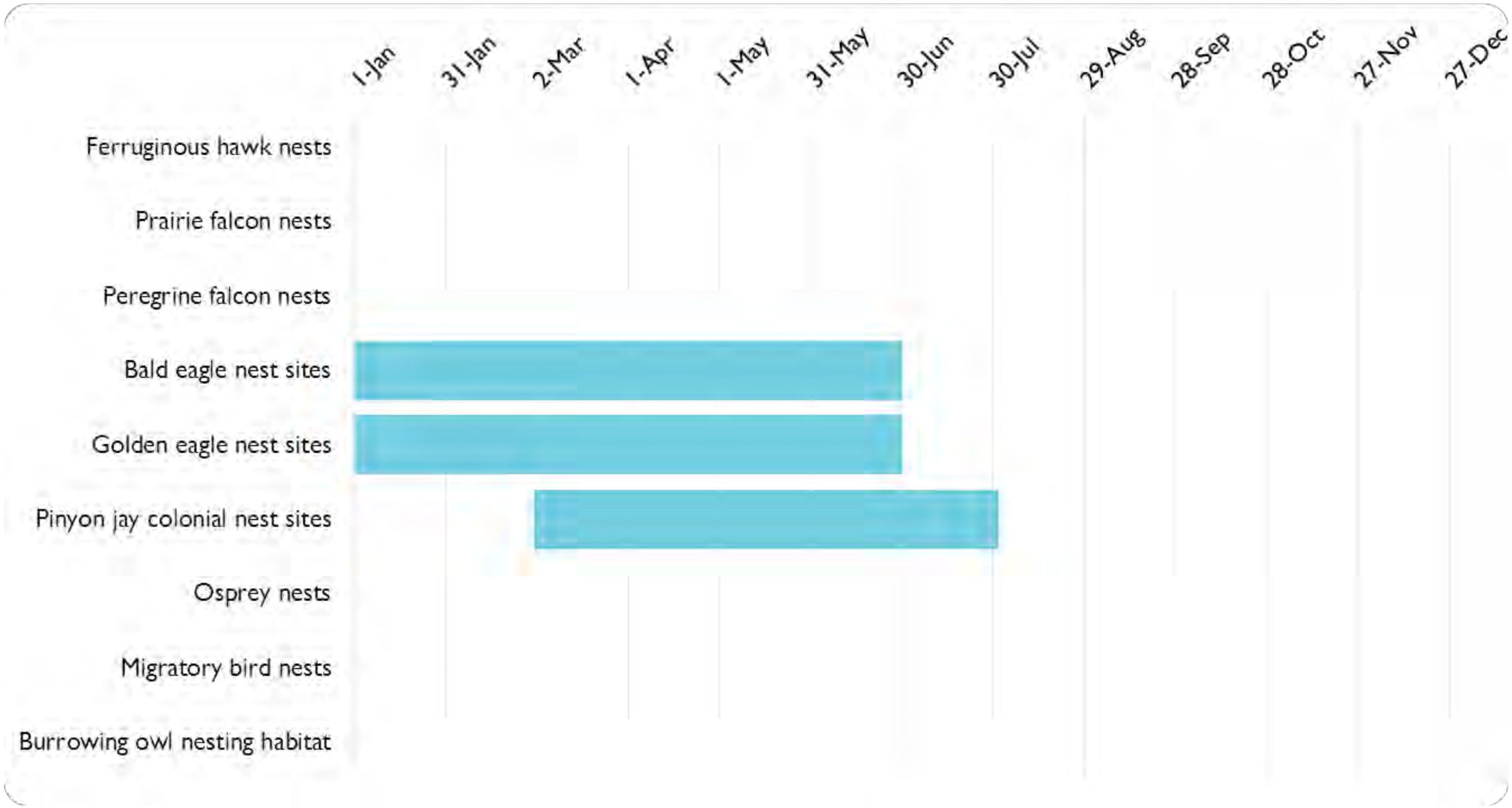
[1] Some areas may have overlapping TLs, but many would not. These TLs are not mapped, so the extent of the overlap is unknown.

Figure D-7
Unmapped Wildlife TLs—Alternatives A, B, and C[1]



[1] Some areas may have overlapping TLs, but many would not. These TLs are not mapped, so the extent of the overlap is unknown.

Figure D-8
Unmapped Wildlife TLs—Alternative D[1]



[1] Some areas may have overlapping TLs, but many would not. These TLs are not mapped, so the extent of the overlap is unknown.

Table D-5
Lease Notices

F-27-LN *COAL RESERVES*	Federal coal resources exist on this lease. Operations authorized by this lease may be altered or modified by the BLM Authorized Officer (at the address shown below) in order to conserve and protect the mineral resources and provide for simultaneous operations.
F-35-LN *NOISE*	This lease is adjacent to a noise sensitive area (Bisti/De-Na-Zin Wilderness Area). Noise sources that operate on a continual basis (more than 8 hours/day) in the long term (more than 1 week in duration) cannot exceed a noise level of 48.6 dBA Leq at the boundary of the wilderness area. If 48.6 dBA Leq does not provide an adequate level of protection from the auditory impact created by lease operations, a stricter stand shall be applied. BLM staff would work with the leaseholder on a case-by-case basis to achieve an acceptable level of noise mitigation. This requirement would not normally apply to transient operations, such as construction, drilling, completion, and workover activities and other temporary sound sources. These short-term activities would be handled on a case-by-case basis during the permitting process. Compliance with the BLM FFO noise policy could result in extended time frames for processing authorizations for development activities, as well as changes in the ways in which developments are implemented.
WO-ESA-7 *ENDANGERED SPECIES ACT SECTION 7 CONSULTATION*	The lease area may now or hereafter contain plants, animals, or their habitats determined to be threatened, endangered, or other special status species. The BLM may recommend modifications to exploration and development proposals to further its conservation and management objective, which is to avoid BLM-approved activity that would contribute to a need to list such a species or its habitat. The BLM may require modifications to or not approve a proposed activity that is likely to jeopardize the continued existence of a proposed or listed threatened or endangered species or to result in the destruction or adverse modification of a designated or proposed critical habitat. The BLM would not approve any ground-disturbing activity that may affect any such species or critical habitat until it completes its obligations under applicable requirements of the Endangered Species Act, as amended (16 USC, Section 1531 et seq.), including completion of any required procedure for conference or consultation.
WO-NHPA *CULTURAL RESOURCES AND TRIBAL CONSULTATION*	This leased area may be found to contain historic properties and/or resources protected under the National Historic Preservation Act (NHPA), the American Indian Religious Freedom Act, the Native American Graves Protection and Repatriation Act, Executive Order 13007, or other statutes and executive orders. The BLM would not approve any ground-disturbing activities that may affect any such properties or resources until it completes its obligations (e.g., State Historic Preservation Officer and tribal consultation) under applicable requirements of the NHPA and other authorities. The BLM may require modification to exploration or development proposals to protect such properties or disapprove any activity that is likely to result in adverse effects that cannot be successfully avoided, minimized, or mitigated.
LN-NIIP **NIIP** *PROTECTION OF NAVAJO INDIAN IRRIGATION PROJECT*	No oil or gas facilities would be installed that would unduly interfere with the construction or development of the area for agriculture purposes in connection with the Navajo Indian Irrigation Project. The lessee must clear it with the Navajo Indian Irrigation Project Manager, prior to the installation of any oil and gas equipment, so that modification or relocation at a later date might be avoided.

LN-NMSO-SSPS
 	
POTENTIAL, SUITABLE AND OCCUPIED HABITAT FOR SPECIAL STATUS PLANT SPECIES
	The lease contains potential, suitable, and/or occupied habitat for special status plant species; therefore, special status plant species clearance surveys may be required prior to approving any surface-disturbing activities within or adjacent to BLM special status plant species' potential, suitable, and occupied habitats. Survey requirements would include the following:
	• Clearance surveys must be conducted by a qualified botanist.
	• The area to be surveyed would include at a minimum the project area plus an additional 328 feet (100 meters) outside the project area.
	• Clearance surveys would be conducted during the blooming season or the period in which the plant species is most easily detected.
	
	Based on the results of the survey, conditions of approval may be applied to land use authorizations and permits that fall within the area of direct/indirect impacts or affected habitat, as appropriate. Possible mitigation strategies may include, but are not limited to, the following:
	• Avoidance/restriction of development such as locating the surface disturbance area away from the edge of occupied or suitable habitat and ideally outside of the area where indirect/direct impacts would occur
	• Minimizing the area of disturbance, utilizing such strategies such, but not limited to, twinning and utilizing existing disturbance and corridors
	• dust abatement measures
	• Signs, fencing, and other deterrents to reduce human disturbance
	• Construction of well sites, roads, and associated facilities outside of the blooming season
	• specialized reclamation procedures, such as, but not limited to, the following:
	    o Separating soil and subsoil layers with barriers to reclaim in the correct order
	    o Using a higher percentage of forbs in the reclamation seed mix to promote pollinator habitat
	    o Collecting seeds for sensitive plant species' genetic preservation, grow-out, and reclamation
	• long-term monitoring of indirect/direct impacts on the species and/or habitat
	• qualified, independent third-party contractors to provide general oversight and ensure compliance with project terms and conditions during construction
	• nonnative or invasive species monitoring and control in occupied and suitable habitat
	• Implement any other on-site habitat protection or improvements, known by best available science to be beneficial

LN-PAL
 	
PALEONTOLOGICAL RESOURCES
	Surface occupancy or use is subject to the following special operating constraints to protect paleontological resources:
	
	• Restrict vehicles to existing roads and trails.
	• A pedestrian survey must be conducted for paleontological material, using a qualified permitted paleontologist determined by the BLM, as part of the permit application for the proposed lease activity in geologic units that are classified on the BLM's PFYC scale as a PFYC U—unknown, 4, or 5, as determined by the BLM Authorized Officer. The survey and report would be used to determine the presence of paleontological material exposed at the surface and, if necessary, the appropriate mitigation of ground-disturbing activities, such as monitoring, avoidance, and/or project redesign.
	• The lessee shall immediately notify the BLM Authorized Officer of any paleontological resources discovered as a result of approved surface-disturbing operations. The lessee shall suspend all activities in the vicinity of such discovery until notified to proceed by the BLM Authorized Officer and shall protect the discovery from damage or looting. The BLM Authorized Officer would evaluate, or would have evaluated, such discoveries after being notified and would determine, after consultation with the operator and the BLM Regional Paleontologist, the appropriate measures to mitigate adverse effects on significant paleontological resources. Upon approval of the BLM Authorized Officer, the operator would be allowed to continue construction through the site, or would be given the choice of either:
	  o Following the BLM Authorized Officer's instructions for stabilizing the fossil resource in place and avoiding further disturbance to the fossil resource or
	  o Following the BLM Authorized Officer's instructions for mitigating impacts on the fossil resource prior to continuing construction through the project area. The lessee is responsible for any cost associated for mitigating paleontology resources discovered as a result of their activities.
	• An avoidance zone around all recorded fossil localities may be applied, based on known extent of resources.
	• When avoidance is not possible, appropriate mitigation may include excavation or collection (data recovery), stabilization, monitoring, protective barriers, and signs.
	
	Project or ground-disturbing activities may be relocated, based on the results of the paleontology field survey.

LN-POD *PLAN OF DEVELOPMENT (POD)*	BLM will take into consideration the impacts to cultural, historical, wildlife, and other resources and BLM will require a plan of development as a lease stipulation on new leases for avoiding, minimizing, and mitigating the impacts to such resources (e.g., in such circumstances where there are wildlife migratory corridors, endangered species habitat, topographic concerns, and/or cultural or historic properties). A POD for the entire lease may be required to be submitted for review and approval, by the BLM Authorized Officer, prior to approval of development actions (APD, Sundry Notices). If a POD is required, it must indicate planned access to well facilities (roads, pipelines, and power lines) and the approximate location of well sites. Should it become necessary to amend the POD, the amendment must be approved prior to the approval of subsequent development action. Deviations from a current POD are not authorized until an amended POD has been approved by the BLM.
LN-BOR *BUREAU OF RECLAMATION DAMS*	This lease is subject to requirements imposed by the U.S. Bureau of Reclamation (Reclamation) to protect Reclamation's facilities and project purposes. No drilling is allowed within 1,500 feet of any Reclamation dam or its appurtenant structures.

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Appendix E
Restrictions Applicable to Bureau of Indian Affairs Fluid Mineral Leasing: Purpose

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Section Page

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations	Full Phrase
APE	area of potential effect
BIA	United States Department of the Interior, Bureau of Indian Affairs
BLM	United States Department of the Interior, Bureau of Land Management
CCNHP	Chaco Culture National Historical Park
CFR	Code of Federal Regulations
dbA	a-weighted decibel
ESA	Endangered Species Act of 1973
FIMO	Federal Indian Minerals Office
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act
NNC	Navajo Nation Code
RMP	resource management plan
RMPA	resource management plan amendment
ROW	right-of-way
TCP	traditional cultural property
THPO	Tribal Historic Preservation Office
USC	United States Code

Appendix E. Restrictions Applicable to Bureau of Indian Affairs Fluid Mineral Leasing: Purpose

Table E-1 in this appendix lists the purposes of the BIA restrictions for leasing fluid minerals, such as oil and gas. They are referred to throughout this draft RMPA and EIS. Stipulations would also apply, where appropriate, to all surface-disturbing activities associated with land use authorizations, permits, and leases issued on BIA-administered lands. The stipulations would not apply to activities and uses where they are contrary to laws, regulations, or specific Tribal guidance.

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Table E-1
Restrictions Applicable to Bureau of Indian Affairs Fluid Mineral Leasing: Purpose

<table>
<tr><th>Line #</th><th>No Action Alternative
Current Management</th><th>Alternative A
Protect and Enhance Natural Ecology</th><th>Alternative B
Preserve and Protect the Cultural and Natural Landscape</th><th>Alternative C
Traditional, Historic, Socioeconomic, and Cultural Lifeways</th><th>Alternative D
Maximize Resource Production in an Environmentally Responsible Manner</th><th>Purpose</th></tr>
<tr><td>1.</td><td colspan="6">Fluid Minerals—General Surface Disturbance</td></tr>
<tr><td>2.</td><td>Action:
No similar stipulation in current BIA management.</td><td>Action:
To minimize surface disturbance, roads, utilities, and pipelines may share ROWs.

Interim reclamation would be required to reestablish local native vegetation in areas of disturbance.

As part of interim reclamation, the footprint of disturbance would be minimized by reclaiming all portions of the cleared areas not needed for production, operations, transportation, or safety purposes by recontouring them with stockpiled topsoil to a final or intermediate contour that blends with the surrounding topography as much as possible.</td><td colspan="2">Action:
Directional drilling may be required, where practical, to collocate wells to reduce road, well pad, and utility surface disturbance. To minimize surface disturbance, roads, utilities, and pipelines may share common ROWs.

Access roads would be designed to follow the contour of the landform and/or mimic lines in vegetation. This can necessitate constructing longer access roads.

To minimize surface disturbance, roads, utilities, and pipelines may share common ROWs.

Interim reclamation would be required to reestablish local native vegetation on well locations. As part of interim reclamation, the footprint of disturbance would be minimized by reclaiming all portions of the cleared areas not needed for production, operations, transportation, or safety purposes by recontouring them with stockpiled topsoil to a final or intermediate contour that blends with the surrounding topography as much as possible.</td><td>Action:
To minimize surface disturbance, roads, utilities, and pipelines may share common ROWs. Site infrastructure to accommodate the needs of the landowner.

Interim reclamation would be required to reestablish local native vegetation on well locations. As part of interim reclamation, the footprint of disturbance would be minimized by reclaiming all portions of the cleared areas not needed for production, operations, transportation, or safety purposes by recontouring them with stockpiled topsoil to a final or intermediate contour that blends with the surrounding topography as much as possible.</td><td>Purpose: To reduce the potential direct and indirect impacts from total surface disturbance, and minimize visual impacts from fluid mineral exploration, development, and operations. These stipulations reflect relevant issues and guidelines described in 25 CFR 211.47, Subparts H and I, and Navajo Nation Code (NNC) Title 18, Chapter 13, Parts 1453, 1506, 1551, and 1554.</td></tr>
</table>

Line #	No Action Alternative *Current Management*	Alternative A *Protect and Enhance Natural Ecology*	Alternative B *Preserve and Protect the Cultural and Natural Landscape*	Alternative C *Traditional, Historic, Socioeconomic, and Cultural Lifeways*	Alternative D *Maximize Resource Production in an Environmentally Responsible Manner*	Purpose
3.	**Action:** Lessees would abide by and conform to appropriate provisions of Title 25, 36, and 43 CFRs and any other applicable regulations and manuals of the Secretary of the Interior now or hereafter in force, relative to the surface leasing, ROWs, and oil and gas leases (including the National Environmental Policy Act, as amended, and Navajo Area Environmental Protection guidelines, the National Historic Preservation Act of 1966, as amended, and Archaeological Resources Protection Act, hereinafter referred to as NEPA, NHPA, and ARPA, and other applicable laws, 36 CFR, Part 800, and 43 CFR, Part 7. **2(a):** Prior to issuing any cultural clearances, the BLM would consult with the Navajo Nation Historic Preservation Department (P.O. Box 2898, Window Rock, Arizona 86515) and provide copies of all historic preservation and related documents associated with an undertaking. The Navajo Nation contracted with the Navajo Area Archaeology Office under Public Law 93-638. **2(b):** Prior to entry on the land or the disturbance of the surface thereof for drilling or other purposes, a lessee would submit a development plan for the surface use to the Area Manager, Farmington Resource Area, Bureau of Land Management (6251 College Blvd., Suite A, Farmington, New Mexico 87402). An environmental analysis would be made by the BLM, in consultation with the BIA Navajo Regional Office, for the purpose of ensuring proper protection of the surface, the natural resources, and the environmental and existing improvements and for assuming timely reclamation of disturbed lands. Upon completion of said environmental analysis, the oil and gas district manager would notify the lessee of the conditions to which the proposed surface-disturbing operations would be subject. (Note: Prior to start of operations, lessees would furnish a copy of their development plans and BLM conditions to the BIA. The BIA reserves the right to require site-specific archaeological surveys and environmental reviews on tracts selected for development, prior to giving concurrence to proposed actions. The BIA would consult with the Navajo Nation prior to concurring on actions.	**Action:** A lessee would abide by and conform to appropriate provisions of Title 25, 36, and 43 CFRs and any other applicable regulations and manuals of the Secretary of the Interior now or hereafter in force, relative to the surface leasing and use, ROWs, and oil and gas leases (including NEPA, NHPA, ESA, ARPA, and other applicable laws). The lessee would comply with all applicable laws of the Navajo Nation or requirements of the Navajo Nation Environmental Protection Agency. This compliance with relevant, applicable, federal and Tribal regulations would also apply to operators on split-estate with Tribal trust surface use agreements and federal minerals.				**Purpose:** Compliance with all relevant federal and Tribal regulations would avoid, minimize, or mitigate direct and indirect impacts from fluid mineral exploration, development, and operations.
4.	**Action:** Lessees will bury all pipelines crossing tillable lands at a minimum of 4 feet or below plow depth, unless other arrangements are made with the Navajo Nation.					**Purpose:** To reduce the total disturbance of agricultural and tillable lands from fluid mineral exploration, development, and operations.

Line #	No Action Alternative *Current Management*	Alternative A *Protect and Enhance Natural Ecology*	Alternative B *Preserve and Protect the Cultural and Natural Landscape*	Alternative C *Traditional, Historic, Socioeconomic, and Cultural Lifeways*	Alternative D *Maximize Resource Production in an Environmentally Responsible Manner*	Purpose
5.	**Action:** The lessee agrees to conduct all operations authorized by this lease with due regard for proper land management; to avoid unnecessary damage to vegetation, timber, crops, or other cover and to improvements (e.g., roads, bridges, cattle guards, and telephone lines); to control soil erosion resulting from the operation; to prevent pollution of soil and water resources; and, whenever required by the BIA Navajo Agency Superintendent or authorized representative, to fence all sump holes or other excavation made by lessee.	**Action:** The lessee agrees to conduct all operations authorized by this lease with due regard for proper land management; to avoid unnecessary damage to wildlife and vegetation, timber, crops, or other cover, and to improvements, such as roads, bridges, cattle guards, and telephone lines; to control soil erosion resulting from the operation to prevent pollution of soil and water resources; and, whenever required by the FIMO Director or authorized representative, to fence all sump holes or other excavations made by the lessee.	**Action:** The lessee agrees to conduct all operations authorized by this lease with due regard for proper land management; to avoid unnecessary damage to cultural resources, burial sites, vegetation, timber, crops, or other cover, and to improvements, such as roads, bridges, cattle guards, and telephone lines; to control soil erosion resulting from the operation to prevent pollution of soil and water resources; and, whenever required by the FIMO Director or authorized representative, to fence all sump holes or other excavation made by the lessee.	**Action:** The lessee agrees to conduct all operations authorized by this lease with due regard for proper land management to avoid unnecessary damage to human health and safety, culturally important properties (CIMPPs) and Indian trust assets, vegetation, timber, crops or other cover, and to improvements, such as roads, bridges, cattle guards, and telephone lines; to control soil erosion resulting from the operation to prevent pollution of soil and water resources; and, whenever required by the FIMO Director or authorized representative, to fence all sump holes or other excavation made by the lessee.	**Action:** The lessee agrees to conduct all operations authorized by this lease with due regard for proper land management; to avoid unnecessary damage to vegetation species, timber, crops, or other cover, and to improvements, such as roads, bridges, cattle guards, and telephone lines; to control soil erosion resulting from the operation to prevent pollution of soil and water resources; and, whenever required by the FIMO Director or authorized representative, to fence all sump holes or other excavation made by the lessee.	**Purpose:** To reduce the total impacts on various natural, cultural, and other resources on Navajo trust and individual Indian allotment lands from fluid mineral exploration, development, and operations.
6.	**Action:** Compliance with the stipulations of NEPA (applies to individual Indian allotment lands only). • Prior to entry upon the leased land or the disturbance of the surface, the lessee shall submit NEPA compliance documentation to FIMO, Navajo Regional Office, P.O. Box 1060, Gallup, New Mexico 87305. An analysis will be made of the plan by the BIA and the FIMO for the purpose of ensuring that the surface, natural resources, the environment, and existing improvements are properly protected and timely reclamation of disturbed areas. Upon completion of the analysis, the BIA shall notify the lessee of the stipulations and the conditions that the proposed surface disturbance operations will be subject to. Notwithstanding any provisions of this lease to the contrary, any drilling, construction, or other operations conducted by the lessees that would disturb the surface or otherwise affect the environment (hereinafter call surface-disturbing operation) shall be subject to, as set forth in this stipulation, the prior approval of the BLM, with consultation with the appropriate surface management agency (e.g., FIMO) and such reasonable conditions as may be required to protect the surface of the leased lands and the environment.	**Action:** (Applies to individual Indian allotment lands only.) The lessee would comply with NEPA and all other applicable laws and regulations. Before leasing and/or surface-disturbing activities begin, the FIMO would complete NEPA compliance documentation for the entire leased area. On completion of the analysis, the FIMO Director would notify the lessee of the stipulations and the conditions that the proposed surface-disturbing operations would be subject to, based on NEPA required mitigation.				**Purpose:** Compliance with all relevant federal and Tribal regulations would avoid, minimize, or mitigate direct and indirect impacts from fluid mineral exploration, development, and operations.

Line #	No Action Alternative *Current Management*	Alternative A *Protect and Enhance Natural Ecology*	Alternative B *Preserve and Protect the Cultural and Natural Landscape*	Alternative C *Traditional, Historic, Socioeconomic, and Cultural Lifeways*	Alternative D *Maximize Resource Production in an Environmentally Responsible Manner*	Purpose
7.	**Action:** Forest and Land Protection Stipulation • Submit in advance to the Secretary for approval a site development and layout plan, construction plan, and any revisions. • Not to cut, destroy, or damage timber without prior authorization of the Secretary, such authorization to be made only where required to pursue necessary mining operations. • Pay for all such timber cut, destroyed, or damaged at rates prescribed by the Area Director [Regional Director], such rates to be determined on the basis of sales of similar timber in the vicinity. Not to interfere with the sale or removal of timber from the land covered by this lease by contractors operating under an approved timber sales contract now in effect or that may be entered into during the period of the lease.	**Action:** The lessee would refrain from destroying or damaging woodlands and/or vegetation. The lessee would pay for all such destroyed or damaged vegetation at rates prescribed by the BIA Navajo Regional Director, based on fair market value.			**Action:** The lessee (or operator with a SUA) would minimize destruction or damage to woodlands. The lessee would pay for all such destroyed or damaged woodlands at rates prescribed by the BIA Navajo Regional Director, based on fair market value.	**Purpose:** To reduce the total disturbance of forest and woodland resources from fluid mineral exploration, development, and operations.
8.	**Action:** If so required by the Regional Director or authorized representative, the lessee shall make it a condition, under the direction of the BLM, any well drilled that does not produce oil or gas in paying quantities, as determined by the said BLM but which is capable of producing water or domestic, agricultural, or livestock use by the lessor. The lessee may remove all pumping equipment installed by the lessee at any well within ninety (90) days after expiration or termination of the lease, otherwise such equipment shall become the property of the lessor, except where such well is left for usage by the lessor or other surface owners, in which case all water pumping equipment and storage tanks shall be left on the premises and shall become the property of the lessor.	**Action:** The lessee, with the consent of the lessor, would condition any well drilled that does not produce oil or gas in paying quantities and is capable of producing water of applicable standards for domestic, agricultural, or livestock use by the lessor. Otherwise, after expiration or termination, the facilities installed by lessee within the lease premises would be removed and the surface properly reclaimed by the lessee.				**Purpose:** To reduce the total disturbance from fluid mineral exploration, development, and operations, while preserving the ability of the Navajo Nation or allottees to benefit from the development of infrastructure, such as abandoned wells, that can be repurposed. Reconditioning wells with the capability to produce water for various uses would provide secondary benefits for the Navajo Nation and allottees.
11.	*Fluid Minerals—ROWs*					
12.	**Action:** Vehicular access to the well site would be limited to the approved access road. Additional unapproved accesses to the well site materializing during the existence of the well would be processed as trespass.	**Action:** To limit impacts on resources, all lessee vehicular access to the well site (on lease or off lease) would be limited to the approved access road. Additional unapproved access by the lessee to the well site materializing during the existence of the well would be cited as a violation of the lease.				**Purpose:** To avoid or minimize the impacts of vehicular traffic and unmanaged use of areas not identified in ROWs or leases related to fluid mineral exploration, development, and operations on Navajo trust and individual Indian allotment lands, while preserving the ability of the Navajo Nation or allottees to benefit from the development.

Line #	No Action Alternative *Current Management*	Alternative A *Protect and Enhance Natural Ecology*	Alternative B *Preserve and Protect the Cultural and Natural Landscape*	Alternative C *Traditional, Historic, Socioeconomic, and Cultural Lifeways*	Alternative D *Maximize Resource Production in an Environmentally Responsible Manner*	Purpose
13.	**Action:** Erosions forming in the access road would be corrected. Preventative measures would be made at the operator's discretion. A permanent side road of the erosion is prohibited.	**Action:** Operators would ensure that dirt roads are maintained in accordance with Clean Water Act 404, 401, and 402 standards and in accordance with BLM standards regarding road maintenance and erosion.			**Action:** For leases on Navajo Tribal trust lands, operators would ensure that dirt roads are maintained in accordance with Clean Water Act 404, 401, and 402 standards and in accordance with BLM standards regarding road maintenance and erosion. For leases on individual Indian allotments, measures to prevent erosion for roads that would not be reclaimed following well abandonment would be established through coordination with the landowner.	**Purpose:** To avoid or minimize the impacts of vehicular traffic and roads related to fluid mineral exploration, development, and operations on Navajo trust and individual Indian allotment lands, while preserving the ability of the Navajo Nation or allottees to benefit from the development. These stipulations are intended to limit the indirect impacts from heavy equipment traffic on roads that are otherwise used by nearby residents who are also affected by poorly maintained roads that increase erosion on their properties.
14.	*Fluid Minerals—Cultural Resources*					
15.	**Action:** No similar stipulation under current BIA management.	**Action:** No similar action.	**Action:** Directional drilling may be required to hide proposed well locations from culturally sensitive viewpoints. These viewpoints may not be on the proposed lease and would be defined through consultation with the BIA, Navajo Nation, other Tribes with TCPs in the viewshed, and local communities.		**Action:** No similar action.	**Purpose:** To reduce direct and indirect impacts from fluid mineral exploration, development, and operations on the visual environment of culturally sensitive viewpoints, such as certain archaeological sites, CUSPs, or other locations important to local communities or tribes. These stipulations reflect relevant issues and guidelines described in 36 CFR 800 and NNC Title 19, Chapter 11.
16.	**Action:** Lessee would not drill any well within 500 feet of any house, structure, or reservoir of water, live stream, or other body of water without the written consent of the Navajo Nation Minerals Department and the Water Code Administration. (Applies to individual Indian allotment lands only) Lessee would not construct any well pad location within 200 feet of any structures or improvements.	**Action:** The lessee would not construct any well pad within 1,320 feet of any house, barn, occupied dwelling, structure on a home site lease, or building unit (including those structures occupied intermittently or seasonally), or other community, municipal, and public structures and buildings, such as chapter houses and schools.			**Action:** (Applies to Navajo Tribal trust lands only.) The lessee would not construct any well pad within 500 feet of any house, barn, occupied dwelling, structure on a home site lease, or building unit (including those structures occupied intermittently or seasonally), or other community, municipal, and public structures and buildings, such as chapter houses and schools. (Applies to individual Indian allotment lands only.) The lessee would not construct any well pad within 200 feet of any structures or improvements—or at a distance approved by the allottee—without the surface owner's written consent.	**Purpose:** To avoid or minimize the impacts of fluid mineral exploration, development, and operations on buildings and structures, along with the public health and safety of those who may reside in or use these buildings. These stipulations reflect guidelines described in 25 CFR 211.47, Subparts D and F, and NNC Title 18, Chapter 13, Parts 1506, 1551, 1552, and 1554, and reflects the BIA's commitment to Tribal sovereignty and self-determination for the Navajo Nation and individual Indian allottees.

Line #	No Action Alternative *Current Management*	Alternative A *Protect and Enhance Natural Ecology*	Alternative B *Preserve and Protect the Cultural and Natural Landscape*	Alternative C *Traditional, Historic, Socioeconomic, and Cultural Lifeways*	Alternative D *Maximize Resource Production in an Environmentally Responsible Manner*	Purpose
17.	**Action:** The BIA would ensure the following stipulations are completed prior to any development: • Exploration Phase: An APE of no less than 100 feet (30 meters) in width would be inventoried on any proposed lines, underdeveloped roads, or trails that provide access to these lines. Archaeological Inventories would be conducted on a 10-acre APE around test well, as well as a 98-foot (30-meter) corridor along any underdeveloped access roads, such as two-tracks to the test wells. The Navajo Nation THPO would be consulted to determine the appropriate avoidance/mitigation strategy for any historic properties located in these corridors. • Production phase: If exploration leads to further development, the BIA would consult with the Navajo THPO to determine the appropriate level of inventory, which would depend on the density of wells and associated infrastructure. At a minimum, the APE of the new gas/oil wells would require archaeological inventories on a 10-acre area around each well and a 98-foot (30-meter) corridor for any pipelines and access roads. If full field development is proposed, then a block survey for the entire 160.00 acres APE may be required. The Navajo THPO would be consulted to determine the appropriate avoidance/mitigation strategy for any historic properties located in the APE.	**Action:** The lessee would comply with the Navajo Nation's Cultural Resources Protection Act (NNCRPA), as well as the Jishchaa' Policy. A site-specific survey of the APE would be conducted before ground-disturbing activities identified under the APD. For leases on individual Indian allotments, the BIA would consult with landowners to determine final disposition of cultural resources and human remains. The Navajo Nation THPO would be requested to recommend the appropriate avoidance or other mitigation strategy for any historic properties, TCPs, or burials in the APE, as well as any other cultural resources that Navajo Nation THPO specifically identifies, with final determination from the Regional Director of the BIA. Per Section 106 of the NHPA and other relevant regulations, the Navajo Nation THPO would consult with Tribes, local communities and Navajo chapters regarding cultural resources.				**Purpose:** To avoid, minimize, or mitigate direct and indirect impacts from fluid mineral exploration, development, and operations by complying with all relevant federal and Tribal regulations related to cultural resources. These stipulations reflect relevant issues and guidelines described in 36 CFR 800, Executive Order 13007, 42 USC 1996, 25 USC 3001–3013, 16 USC 470(aa–mm), and NNC Title 19, Chapter 11, Parts 1001–1061.
18.	**Action:** Lands held in trust by the Secretary for an Indian tribe or any individual member thereof, or held in restricted fee status, shall continue to be so managed or held by the Secretary (16 USC Chapter 1, Subchapter Lix-G: CCNHP §410ii–5).	**Action:** Lands held in trust by the Secretary of the Interior for an Indian Tribe or any individual member thereof or held in restricted fee status would continue to be so managed or held by the Secretary. Management of CCNHP under the general management plan (as amended in 2012) is limited to NPS-administered lands and would not abridge the BIA's trust responsibilities to manage individual Indian allotments within the boundaries of CCNHP.				**Purpose:** To ensure the rights and abilities of Navajo allottees to manage their own lands, even if those lands are within the boundaries of CCNHP, which may have management goals that conflict with the desires of the allottee.

Line #	No Action Alternative *Current Management*	Alternative A *Protect and Enhance Natural Ecology*	Alternative B *Preserve and Protect the Cultural and Natural Landscape*	Alternative C *Traditional, Historic, Socioeconomic, and Cultural Lifeways*	Alternative D *Maximize Resource Production in an Environmentally Responsible Manner*	Purpose
19.	*Fluid Minerals—Public Health and Safety*					
20.	**Action:** The lessee would not use or permit to be used any part of said leased land for unlawful conduct or purposes whatsoever. Lessee would not use or permit to be used any of said leased land for the manufacture, sale, gift, transportation, or storage of intoxicating liquors, beverages, or drugs. In the event any representative of lessee or its contractor or subcontractor, employed in connection with the operations on the lease premises, would be responsible for any of the unlawful acts described in this clause, the BLM would give lessee information as to such violation(s), with a copy of the notice to the BIA and the Navajo Nation. Lessee would immediately take steps to cure the violation, including the termination or transfer of such employee (25 CFR, Subpart 162.604; 18 USC, Sections 1151, 1154, and 1156, as amended).	**Action:** The lessee would not use or permit to be used any part of said leased land for unlawful conduct or purposes whatsoever. The lessee would not use or permit to be used any of said leased land for illegal activities, such as the manufacture, sale, gift, transportation, or storage of intoxicating liquors, beverages, or drugs. In the event any representative of the lessee or its contactor or subcontractor, employed in connection with the operations on the lease premises, were responsible for any of the unlawful acts described in this clause or in the 2017 Legislation No. 0117-17—Navajo Nation Law Against Human Trafficking—that amended the Navajo Nation Criminal Code Title 17, then the BIA or BLM would give lessee information as to such violations, with a copy of the notice to the BIA or BLM, as appropriate, and the Navajo Nation and Federal Law Enforcement, as appropriate. The lessee would immediately take steps to cure the violation, including terminating or transferring such employee (25 CFR, Subpart 162.604; 18 USC, Sections 1151, 1154, and 1156, as amended). The lease may be subject to cancellation.				**Purpose:** To avoid or minimize the unwanted indirect social impacts from fluid mineral exploration, development, and operations—for example, illegal drug or alcohol use on Navajo lands.
23.	*Fluid Minerals—Water Resources*					
24.	**Action:** Upon the request of the Navajo Nation Water Code Administration, or if so required by the Navajo Regional Director or authorized representative, and under the direction of the Field Manager, BLM, lessee would condition any well drilled that does not produce oil or gas in paying quantities and is capable of producing water satisfactorily for domestic, agricultural, or livestock use by the landowner. Otherwise, after the expiration or termination of the lease, lessee would remove all pumping equipment installed by lessee at any well and then would plug the well.					**Purpose:** To avoid or minimize the impacts of fluid mineral exploration, development, and operations on Navajo trust and individual Indian allotment lands, while preserving the ability of the Navajo Nation or allottees to benefit from the development of infrastructure, such as reconditioning abandoned wells with the capability to produce water for various uses.
22.	**Action:** (Applies to individual Indian allotment lands only.) The lessor expressly reserves the right to use sufficient gas free of charge for all stoves and inside lights in the principle dwelling house on said lands by making connection at the lessor's own expense with the well or wells thereon, the use of such gas to be at the lessor's risk at all times.	**Action:** (Applies to individual Indian allotment lands only.) For reasons of public health and safety, any new leases granted on individual Indian allotments would no longer include the previous lease stipulation, wherein "the lessor expressly reserves the right to use sufficient gas free of charge for all stoves and inside lights in the principle dwelling house on said lands by making connection at his own expense with the well or wells thereon, the use of such gas to be at the lessor's risk at all times."				**Purpose:** To address safety concerns related to allottee use of natural gas that does not contain mercaptans, which gives the gas a distinctive odor and allows users to know when leaks have occurred.
25.	**Action:** Navajo grazing rights would be protected, and the Navajo Nation's rights respecting the use of water would be unimpaired.	**Action:** The Navajo Nation's rights respecting the use of water would be unimpaired. The lessee would not use any waters of the Navajo Nation, such as wells, tanks, rivers, springs, washes, creeks, and stock water reservoirs, without a water use permit issued by the Navajo Nation Water Code Administration. The lessee would not drill any water wells for its use without a drilling permit from the Water Code Administration.				**Purpose:** To avoid or minimize the impacts on the Navajo Nation's water use from fluid mineral exploration, development, and operations. These stipulations reflect relevant issues and guidelines described in NNC Title 18, Chapter 13, Parts 1506 and 1551–1554, and the BIA's commitment to Tribal sovereignty and self-determination for the Navajo Nation.

Line #	No Action Alternative *Current Management*	Alternative A *Protect and Enhance Natural Ecology*	Alternative B *Preserve and Protect the Cultural and Natural Landscape*	Alternative C *Traditional, Historic, Socioeconomic, and Cultural Lifeways*	Alternative D *Maximize Resource Production in an Environmentally Responsible Manner*	Purpose
27.	*Fluid Minerals—Livestock and Grazing*					
28.	**Action:** Navajo grazing rights would be protected, and the Navajo Nation's rights respecting the use of water would be unimpaired.	**Action:** Navajo grazing rights will be protected. The lessee will negotiate and compensate the landowner(s) for all surface use, including grazing lands.				**Purpose:** To avoid or minimize impacts from fluid mineral exploration, development, and operations on grazing rights on Navajo trust and individual Indian allotment lands and ensure that the landowner would be compensated for any impacts from development, given how grazing rights and the practice of animal husbandry are central to the Navajo historically and to the present day. These stipulations reflect relevant issues and guidelines described in NNC Title 18, Chapter 13, Parts 1506 and 1551, and the BIA's commitment to Tribal sovereignty and self-determination for the Navajo Nation.
29.	**Action:** No similar stipulation in current BIA management.	**Action:** Any range improvement (e.g., fences, pipelines, and ponds) disturbed by construction activities would be restored immediately following construction and would be restored to the condition they were in, prior to disturbance or better.				**Purpose:** To avoid or minimize impacts from fluid mineral exploration, development, and operations on grazing, given how the practice of animal husbandry are central to the Navajo historically and to the present day.
30.	*Fluid Minerals–Socioeconomics*					
31.	**Action:** As to the field operations carried out on the leased premises, the lessee shall make reasonable efforts to employ Navajo labor in all positions for which they are qualified. In the event of a conflict between the terms of the lease and those contained within this Exhibit A, the terms contained within this Exhibit A shall control.	**Action:** All hiring practices would comply with Navajo or Indian preference laws in effect. The lessee would make reasonable efforts to employ Navajo or Indian labor in all positions for which they are qualified.				**Purpose:** To avoid or minimize the potential for disparate secondary impacts from fluid mineral exploration, development, and operations, where Navajo communities experience negative environmental impacts while benefitting economically from jobs in the fluid mineral extraction industry.

Line #	No Action Alternative *Current Management*	Alternative A *Protect and Enhance Natural Ecology*	Alternative B *Preserve and Protect the Cultural and Natural Landscape*	Alternative C *Traditional, Historic, Socioeconomic, and Cultural Lifeways*	Alternative D *Maximize Resource Production in an Environmentally Responsible Manner*	Purpose
32.	*Fluid Minerals—Yádiłhił and Light Pollution*					
33.	**Action:** No similar stipulation in current BIA management.	**Action:** Develop and implement measures to control lighting and light resulting from flaring on well sites and off-site facilities to limit light pollution. The lighting measures should consider sensitive wildlife habitat or nest locations and could include the following: • Down lighting • Flare shielding • Alternate lighting colors	**Action:** Develop and implement measures to control lighting and light resulting from flaring on well sites and off-site facilities to limit light pollution. The lighting measures should emphasize limiting light pollution at views seen from key cultural resources identified by the NPS, Navajo Nation, or other tribes. The lighting measures should include the following: • Down lighting • Flare shielding • Alternate lighting colors	**Action:** Develop and implement measures to control lighting and light resulting from flaring on well sites and off-site facilities, to protect *Yádiłhił* and limit light pollution. The lighting measures should be considerate of locations significant to local residents, such as any house, barn, occupied dwelling, structure on a home site lease, or building unit (including those structures occupied intermittently or seasonally), or other community, municipal, and public structures and buildings, such as chapter houses and schools. The lighting measures should include the following: • Down lighting • Flare shielding • Alternate lighting colors • Timing restrictions Operators are required to notify the community one week in advance of flaring and to provide flaring information.	**Action:** Develop and implement measures to control lighting and light resulting from flaring on well sites and off-site facilities, to limit light pollution. Operators are required to notify the community one week in advance of flaring and to provide flaring information.	**Purpose:** To avoid or minimize the potential for light pollution or Yádiłhił, impacts from fluid mineral exploration, development, and operations (for example, flaring or lighting at well locations and oil and gas facilities) on various resources such as sensitive wildlife habitat and nest locations; cultural resources and CUSPs; or the ability of Tribes to complete certain ceremonies within the planning area. These stipulations reflect relevant issues and guidelines described in 25 CFR 211.49.
34.	*Fluid Minerals—Noise*					
35.	**Action:** No similar stipulation in current BIA management.	**Action:** Noise levels at nest sites for golden eagles and ferruginous hawks would be no higher than 48.6 dB(A).	**Action:** Noise levels at the boundary of CCNHP and Chacoan outlier sites would be no higher than 35 dB(A) at night.	**Action:** Noise levels at locations significant to residents, such as any house, barn, occupied dwelling, structure on a home site lease, or building unit (including those structures occupied intermittently or seasonally), or other community, municipal, and public structures and buildings, such as chapter houses and schools, and CIMPPs, would be no higher than 35 dB(A) at night.	**Action:** Same as the No Action Alternative.	**Purpose:** To reduce noise impacts from fluid mineral exploration, development, and operations on sensitive receptors, such as wildlife, cultural resources, and locations significant to residents. These stipulations reflect relevant issues and guidelines described in 25 CFR 211.49.

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Appendix F
Summary Comparison of Environmental Consequences

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ACRONYMS AND ABBREVIATIONS

Acronym	Full Phrase
ACEC	area of critical environmental concern
APD	application for permit to drill
AQRV	air quality related value
BIA	United States Department of the Interior, Bureau of Indian Affairs
BLM	United States Department of the Interior, Bureau of Land Management
CCNHP	Chaco Culture National Historic Park
CIMPP	culturally important property
COA	condition of approval
CSU	controlled surface use
CWA	Clean Water Act
dBA	A-weighted decibel
EIS	environmental impact statement
FFO	Farmington Field Office
FIMO	Federal Indian Minerals Office
GMU	game management unit
ITA	Indian trust asset
NEPA	National Environmental Policy Act of 1969
NRHP	National Register of Historic Places
NSO	no surface occupancy
PFC	proper functioning condition
RCP	regional comprehensive plan
RFD	reasonably foreseeable development
RMP	resource management plan
RMPA	resource management plan amendment
ROW	right-of-way
TL	timing limitation
VCC	vegetation condition class
WSA	wilderness study area

Appendix F. Summary Comparison of Environmental Consequences

Table F-1, below, summarizes the environmental consequences of the BLM and BIA Alternatives on the resources and resource uses in the decision areas. (See **Chapter 3** for a detailed analysis of environmental consequences.) Under all BIA alternatives, the 2019 RFD projects that up to approximately 510 new wells would be drilled in the BIA mineral decision area over the next 20 years. This includes an estimated 141 new wells on Navajo Tribal trust minerals and another 369 new wells on individual Indian allotment minerals (**Appendix I**). New surface disturbance in the BIA mineral decision area is estimated in the 2019 RFD to be 2,100 acres, including 1,450 acres of individual Indian Allotted minerals and 650 acres of Navajo Tribal trust minerals (**Appendix I**).

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Table F-1
Summary Comparison of Environmental Consequences of the Alternatives

Resource Affected	No Action Alternative	Alternative A	Alternative B (Includes BLM Sub-Alternatives B1 and B2)	Alternative C (Includes BLM Sub-Alternatives C1-C6)	Alternative D
Air Quality	**BLM:** No direct impacts; indirect impacts would occur over the short and long term related to fugitive dust during construction and the introduction of new sources of air pollutants and greenhouse gases. **BIA:** Fluid mineral leasing actions would have no direct impacts. Indirect impacts from oil and gas development would be as described above in the BLM summary.	**BLM:** Impacts would be similar to the No Action Alternative but would be reduced because a larger area would be closed to development. This would maintain or minimize impacts related to fugitive dust before surface-disturbing activities begin. **BIA:** See the No Action Alternative.	**BLM:** Under the alternative and sub-alternatives, direct and direct impacts would be similar to Alternative A, but they would be further reduced because the largest area would be closed to development. **BIA:** See the No Action Alternative.	**BLM:** Under the alternative and each of the sub-alternatives, direct and direct impacts would be similar to Alternatives A and B to varying degrees, depending on how much area is closed to leasing or surface disturbance. Impacts could therefore be greater than those under Alternatives A and B. **BIA:** See the No Action Alternative.	**BLM:** As a similar amount of land would be open to development, impacts would be the same as those under the No Action Alternative. **BIA:** See the No Action Alternative.
Geology	**BLM:** Direct impacts over the long term would be the greatest under this alternative. This is because surface-disturbing activities from oil and gas development and ROW construction would allow for continued potential damage to traditional mineral gathering areas and culturally significant geologic formations in areas that are disturbed. **BIA:** The BIA would continue to limit surface disturbances associated with new roads and facilities. This could limit the risk of impacts on traditional mineral gathering areas and culturally significant geologic formations.	**BLM:** Direct impacts over the long term would be similar to those under the No Action Alternative; however, surface use restrictions (NSO, CSU, and TL) would be applied under this alternative, which could reduce impacts. **BIA:** Increased reclamation and restrictions on surface use could result in less potential for damage to traditional mineral gathering areas and culturally significant geologic formations.	**BLM:** Under the alternative and sub-alternatives, direct and direct impacts would be similar to those under the No Action Alternative; designation of surface disturbance stipulations (NSO, CSU, and TL) would be the most restrictive, such that the impacts would be fewest under this alternative. **BIA:** BIA management affecting surface disturbance and its impacts on geologic resources would be slightly more restrictive than that under BIA Alternative A, which could further reduce those impacts described.	**BLM:** Under alternative and each of the sub-alternatives, direct and direct impacts would be similar to those under Alternatives A and B, to varying degrees, depending on how much area is subject to surface use restrictions. Impacts could therefore be greater than those under Alternatives A and B. **BIA:** Same as Alternative B.	**BLM:** Same as the No Action Alternative. **BIA:** Impacts would be similar to but less than those described under the No Action Alternative.
Minerals	**BLM:** Surface occupancy stipulations in high-potential unleased acres and closures and moderate-potential unleased areas would have direct impacts on access to oil and gas resources. Indirect impacts would be the economic feasibility of developing a site should there be limitations on surface disturbances. No high-potential unleased acres would be closed. **BIA:** Current management would continue. Impacts would be like those described above.	**BLM:** Impacts would be greater than those under the No Action Alternative, as more high- and moderate- potential unleased areas would be closed to leasing or subject to NSO stipulations. **BIA:** Restrictions on oil and gas leasing would reduce surface use and thus impacts associated with it, as described in the No Action Alternative.	**BLM:** Under the alternative and sub-alternatives, direct and indirect impacts on fluid minerals would be greatest under this alternative, as the greatest amount of high- and moderate-potential unleased acres would be closed to leasing or subject to no surface occupancy stipulations. As a result, the projected number of wells drilled under this alternative would be the fewest. **BIA:** Restrictions on oil and gas development and its associated impacts would be similar to those under Alternative A.	**BLM:** Like the No Action Alternative, under the alternative and sub-alternatives, no unleased acres with high development potential would be closed to fluid mineral leasing; however, a greater amount would be subject to NSO stipulations, when compared with the area of unleased high-potential acres closed or subject to NSO stipulations under the No Action Alternative. **BIA:** Restrictions on oil and gas development and its associated impacts would be similar to those under Alternative A.	**BLM:** Impacts under this alternative would be similar to those under the No Action Alternative. This is because there would not be any closure of high-potential unleased acres for fluid mineral development, and the same amount of moderate potential unleased acres would be subject to NSO stipulations. **BIA:** Restrictions on oil and gas development and its associated impacts would be similar to those under Alternative A.

Resource Affected	No Action Alternative	Alternative A	Alternative B (Includes BLM Sub-Alternatives B1 and B2)	Alternative C (Includes BLM Sub-Alternatives C1-C6)	Alternative D
Public Health and Safety	**BLM:** Direct impacts caused by noise and light from surface facilities could occur over the short and long term. Other indirect impacts, such as increased traffic and air and water pollution, could also occur over the short and long term. The fewest acres would be closed or subject to NSO under this alternative; thus, risks to public health and safety would be the greatest. **BIA:** Risks to public health and safety would be greatest under this alternative; impacts would be similar to those described above.	**BLM:** Impacts described under the No Action Alternative would be fewer under Alternative A. This is because more areas would be closed to leasing or subject to NSO stipulations that would particularly reduce localized noise, light, and other health impacts in these commonly used areas. **BIA:** Management and associated impacts would be similar to those described above.	**BLM:** Impacts described under No Action Alternative would be the least under the Alternative B and sub-alternatives, as the most acres would be closed to leasing or subject to NSO. **BIA:** Similar to Alternative A.	**BLM:** The slightly reduced number of wells projected under this alternative would result in direct and indirect impacts similar to those described under the No Action Alternative. **BIA:** Similar to Alternative C.	**BLM:** Same as the No Action Alternative. **BIA:** Similar to Alternative A.
Water Resources	**BLM:** Direct and indirect impacts would occur over the short and long term, as no management actions regarding the reuse of produced water and flowback water in oil and gas development would apply. This could reduce or deplete natural water supplies. **BIA:** For fluid mineral ROWs, erosions associated with access roads would continue to be corrected. This would continue to minimize degradation of water resource conditions and water quality from this erosion. Drilling would not be allowed within 500 feet of any house or similar structure, which would continue to minimize impacts on water resources.	**BLM:** Alternative A would reduce impacts on water resources described under the No Action Alternative, as regulations regarding the reuse of produced water and flowback water in oil and gas development would apply; further, closing areas to leasing and applying NSO stipulations around water resources would reduce impacts. **BIA:** Management and impacts would be similar to those under the No Action Alternative, but there would be greater protections to homes and similar structures. This would reduce impacts, as described under the No Action Alternative.	**BLM:** Impacts on water resources would be fewest under this alternative and sub-alternatives. This is because protections around resources would be greater than under all other alternatives through closures and the application of NSO and CSU stipulations. Alternative B would also minimize the depletion of natural water supplies more than under the No Action Alternative. **BIA:** The impacts on water resource conditions, water quality, and water supplies from the prohibition on drilling wells would be the same as those under BIA Alternative A.	**BLM:** Under the alternative and sub-alternatives, management around seeps and springs would be the same as described under the No Action Alternative. Regulations on reusing produced water and flowback water for oil and gas development would be the same as those under Alternative B. This alternative would have similar impacts on water resources as the No Action Alternative. **BIA:** The impacts on water resource conditions, water quality, and water supplies from the prohibition on drilling wells would be the same as those under BIA Alternative A.	**BLM:** Management and impacts would be the same as those under Alternative C. **BIA:** The impacts on water resource conditions and water quality from maintaining dirt roads would be similar to those under BIA Alternative A. The impacts under BIA Alternative D, however, would be for only Navajo Tribal trust lands.
Upland Vegetation and Soils	**BLM:** Direct and indirect impacts on these resources would occur over the short and long term through degradation and loss of vegetation and erosion and compaction of soils, caused by surface disturbance. The No Action Alternative would provide the least protection to upland vegetation and soils, including fragile soils. **BIA:** The BIA would continue to have no stipulations on infrastructure placement to minimize surface disturbance. The placement of infrastructure could continue to spread across the landscape, affecting vegetation and soil conditions from soil compaction and wind and water erosion.	**BLM:** Alternative A would protect upland vegetation and soils, including fragile and sensitive soils, through closures to fluid mineral leasing, NSO stipulations, and ROW exclusion areas. Alternative A formalizes treatment purposes, which would improve general soil health in the long term. Further, there would be no mechanical or surface-disturbing vegetation treatments on lands managed to protect wilderness characteristics. **BIA:** Roads, utilities, and pipelines may share common ROWs to minimize surface disturbance. Collocating infrastructure would minimize surface disturbances that can destroy or disturb vegetation and cause soil compaction and wind and water erosion. This would maintain vegetation and soil resiliency more than would the No Action Alternative.	**BLM:** The impacts on vegetation and soil resources under this alternative and sub-alternatives would be similar to those under Alternative A; however, there would be fewer surface-disturbing limitations or prohibitions, resulting in more opportunities to affect vegetation and soil conditions. **BIA:** The impacts on soil resources from range improvements would be the same as those under Alternative A.	**BLM:** The impacts on vegetation and soil resources would be the same as those under the No Action Alternative. As with the No Action Alternative, vegetation and soils on lands with wilderness characteristics would not receive any special management; impacts therefore would be similar to those under the No Action Alternative. **BIA:** The impacts on vegetation and soil resources from range improvements would be the same as those under Alternative A.	**BLM:** The impacts on upland vegetation and soil resources would be similar to those under the No Action Alternative. Vegetation and soils in lands with wilderness characteristics would not receive any special management; however, Alternative D would formalize treatment purposes in GMUs. **BIA:** The impacts on vegetation and soil resources from range improvements would be the same as those under Alternative A.

Resource Affected	No Action Alternative	Alternative A	Alternative B (Includes BLM Sub-Alternatives B1 and B2)	Alternative C (Includes BLM Sub-Alternatives C1-C6)	Alternative D
Forestry	**BLM:** No impacts would occur, beyond what is analyzed in the 2003 RMP. **BIA:** The BIA would continue to apply forest and land protection stipulations. These would prevent cutting, destroying, or damaging timber without prior authorization of the Secretary of the Interior. Payment for all timber cut, destroyed, or damaged would be required, at rates prescribed by the Area Director; interfering with the sale or removal of timber from the land would be restricted.	See the No Action Alternative. BIA: Requiring interim reclamation and applying larger setbacks from structures and water bodies could contribute to reduced levels of localized surface disturbance projected, compared with the BIA No Action Alternative. This would result in less potential for impacts on forestry resources when compared to the BIA No Action Alternative.	See the No Action Alternative. BIA: BIA management affecting surface disturbance, and the impacts of that management on forestry resources, would be similar to those under BIA Alternative A. The exception is that requiring directional drilling and collocation of facilities could further reduce surface disturbance projected under this alternative, compared with the BIA No Action Alternative. This would result in less potential for impacts on commercial and noncommercial forestry resources.	See the No Action Alternative. BIA: Requirements for lessees to avoid damaging forest resources would have the same impacts as described under BIA Alternative A. BIA management affecting surface disturbance, and the impacts of that management on forestry resources, would be the same as those under BIA Alternative B.	See the No Action Alternative. BIA: Requirements for lessees to avoid damaging forest resources would have the same impacts as described under BIA Alternative A. Requiring interim reclamation could contribute to reduced surface disturbance under this alternative, compared with the BIA No Action Alternative.
Riparian Areas and Wetlands	**BLM:** Riparian areas and wetlands would experience indirect impacts from development of well pads, roads, power lines, and other infrastructure near these areas. Surface disturbance associated with these activities would increase erosion or runoff rates. It also would increase sediment loading, which could move wetlands and riparian areas away from PFC and would increase the likelihood for unmitigated loss. **BIA:** The lessee would not drill within 500 feet of any reservoir, live stream, or other waterbody without written consent of the Navajo Nation Minerals Department and the Water Code Administration. This restriction can help to distance development from riparian and wetland areas, minimizing impacts.	**BLM:** Impacts described under the No Action Alternative would be reduced, as these areas would be subject to NSO, CSU, or TL stipulations. Further, surface occupancy would be prohibited around certain riparian areas, wetlands, and seeps and springs. **BIA:** Impacts on wetlands and riparian areas would be reduced, compared with those under the No Action Alternative. This is because lessees would be required to avoid unnecessary damage to vegetation, to control soil erosion, and to prevent soil and water pollution, which would minimize impacts on wetland and riparian communities.	**BLM:** This alternative and sub-alternatives would have the least impact on riparian areas and wetlands, as all areas would be subject to NSO, CSU, or TL stipulations. **BIA:** All actions affecting riparian areas and wetlands described under BIA Alternative A would also apply to BIA Alternative B. Additionally, BIA Alternative B would require directional drilling in some areas to hide proposed well locations from culturally sensitive viewpoints. These viewpoints overlapping wetlands and riparian areas would protect them from surface disturbance.	**BLM:** Sub-Alternatives C1 through C6 would manage NSO stipulations for varying distances around the CCNHP and key outlier boundaries. C6 would include a 4-mile closure as well as a 2-mile NSO. Sub-Alternative C1 would have the fewest extensive NSO around these boundaries; thus, fewer acres of wetland and riparian areas would fall under this stipulation, compared with other sub-alternatives. Conversely sub-alternative C5 would manage the most extensive NSO zone around these areas, and C6 would include a closure and NSO. **BIA:** Impacts on riparian areas and wetlands would be the same as those described under Alternative A.	**BLM:** Impacts would be similar to those described under the No Action Alternative; however, Alternative D would likely have the greatest impact on riparian areas and wetlands, as more areas would be open to leasing, subject to standard terms and conditions compared to the No Action Alternative. **BIA:** Impacts on riparian areas and wetlands would be the same as those described under Alternative A.
Wildlife	**BLM:** Direct impacts could be significant, as there would be no stipulations that operators avoid harassing wildlife at well pads, facilities, or associated infrastructure. Other impacts could include loss or degradation of available habitat to development of well pads and infrastructure. **BIA:** This alternative would be the least protective of wildlife.	**BLM:** Under Alternative A impacts would be similar to those described under the No Action Alternative; however, closures and restrictions on surface use and well development would reduce disturbance and changes in habitat and, in turn, would lessen impacts on wildlife that significantly disrupt normal behavior patterns. Such patterns include breeding, feeding, or sheltering at well pads, facilities, or associated infrastructure. **BIA:** Surface disturbance would be reduced, which would reduce impacts on wildlife, compared with the No Action Alternative. Prohibiting unnecessary damage to vegetation and requiring lighting mitigation measures would also reduce impacts. This alternative would be the most protective of wildlife.	**BLM:** Alternative B and sub-alternatives would have impacts on wildlife similar to those described under Alternative A, as similar closures and restrictions would apply. **BIA:** Impacts would be similar to those under BIA Alternative A, except that surface disturbance impacts on wildlife could be further reduced.	**BLM:** Under this alternative and sub-alternatives, conducting vegetation treatments to prioritize wildlife habitat would increase habitat effectiveness and reduce habitat degradation. Compared with the No Action Alternative, wildlife and migratory bird habitat would receive more protection, due to vegetation treatments in GMUs. **BIA:** Impacts would be the same as those under BIA Alternative B.	**BLM:** Same as under the No Action Alternative. **BIA:** Impacts of surface disturbance would be the same as those under the BIA No Action Alternative. Impacts of vegetation protection and lighting measures would be the same as those under BIA Alternative B.

Resource Affected	No Action Alternative	Alternative A	Alternative B (Includes BLM Sub-Alternatives B1 and B2)	Alternative C (Includes BLM Sub-Alternatives C1-C6)	Alternative D
Noxious Weeds	**BLM and BIA:** No impacts beyond what is analyzed in the 2003 RMP would occur.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.
Special Status Species	**BLM:** Direct and indirect impacts would be significant over the short and long term; current management direction and prevailing conditions derived from existing planning documents would continue. Disturbance from fluid mineral exploration and development could reduce the size and quality of habitat, which could result in damage or direct mortality of special status species. **BIA:** Without measures to control light and lighting, special status birds and wildlife would be affected by altering behaviors for foraging, reproduction, communication, and other critical behaviors.	**BLM:** Impacts described under the No Action Alternative would be reduced through NSO stipulations in occupied or suitable habitat for special status species from fluid mineral exploration and development. **BIA:** Compared with the No Action Alternative, controlling light and lighting would reduce the effects of lighting on special status wildlife and bird foraging, reproduction, and communication.	**BLM:** Impacts would be similar to those under Alternative A. This is because of the additional closures and NSO stipulations that would reduce the amount of surface disturbance and habitat fragmentation; habitat loss and mortality could still occur in areas not subject to specific protections. **BIA:** Compared with the No Action Alternative, impacts on special status species from artificial lighting would be reduced.	**BLM:** Overall impacts from oil and gas development on special status species habitat and individuals would be similar to those under the No Action Alternative. This is because the total amount of surface disturbance and habitat fragmentation throughout the decision area is likely to be similar, which could risk mortality and habitat loss in areas not subject to specific protections.. **BIA:** Same as Alternative B.	**BLM:** The same as those under the Alternative C. **BIA:** Same as Alternative B.
Cultural Resources	**BLM:** Impacts could be significant and long term under this alternative. This is because a large portion of planning area would be open to leasing, with only standard terms and conditions, which could diminish the historic and physical integrity of properties and CIMPPs, such as setting or feeling. **BIA:** Impacts would be similar to those described above.	**BLM:** The potential impacts described under the No Action Alternative would be reduced under this alternative. This is because a greater area would be closed to leasing, NSO stipulations would apply to more acres, and more areas would be managed to protect wilderness characteristics. **BIA:** Stipulations that require consultation with Tribes, local communities and chapters, as well as setbacks from CIMPPs and structures would result in fewer potential direct and indirect impacts on cultural resources, when compared with the BIA No Action Alternative.	**BLM:** This alternative and sub-alternatives would reduce potential direct and indirect impacts on cultural resources to the greatest degree. This is because the most acres would be closed to leasing, and surface occupancy would be the most restricted under this alternative. **BIA:** The type of impacts under Alternative B would be the same as those described under Alternative A. Stipulations to limit noise at Chacoan sites and light pollution at certain locations, including some CIMPPs, could reduce potential impacts on cultural resources.	**BLM:** Under Alternative C and each sub-alternative, certain vegetation treatments focused on reducing impacts on ITAs and CIMPPs would result in less potential for impacts on historic properties and CIMPPs, when compared with the No Action Alternative. This includes no similar management. Leasing stipulations under this alternative would also reduce direct impacts on historic properties; specifically, CCNHP, Pueblo Pintado and Kin Bineola. **BIA:** The type of impacts and management under Alternative C would be the same as those impacts under Alternative B.	**BLM:** Impacts would likely be the same as those described under the No Action Alternative. **BIA:** Stipulations under Alternative D would continue the current lease stipulations under the No Action Alternative; therefore, the type of impacts on cultural resources for continuing this current management would be the same under Alternative D as under the No Action Alternative.

Resource Affected	No Action Alternative	Alternative A	Alternative B (Includes BLM Sub-Alternatives B1 and B2)	Alternative C (Includes BLM Sub-Alternatives C1-C6)	Alternative D
Native American Tribal Interests and Uses	**BLM:** Impacts under this alternative could have direct short-term and long-term impacts on ITAs and CIMPPs through degradation and loss. For example, areas used for traditional plant gathering may be destroyed in the course of fluid mineral leasing. These impacts would be greatest in areas managed as open to leasing with standard stipulations, as surface disturbance would be the most unrestricted. Development in CSU and NSO areas could indirectly diminish the ability of Tribes to conduct ceremonies or otherwise use these CIMPPs, which could affect the well-being of certain Tribal members. **BIA:** There would be the potential for direct or indirect impacts on CIMPPs, and the BIA would manage to avoid impacts on water-related ITAs for the Navajo Nation. How CIMPPs or ITAs could be specifically affected would generally be determined through the Section 106 process and consultation with Tribes, in particular at the site-specific APD level.	**BLM:** Impacts described under the No Action Alternative could also occur; however, restrictions on surface use would reduce such impacts. Also, restriction zones around the CCNHP and Chacoan outlier sites would reduce potential for direct impacts on CIMPPs and ITAs or indirect impacts; examples are reduced integrity in setting or feeling or impacts from vibrations. As part of the Section 106 process of the NHPA, the BLM would consult with Tribes with cultural affinity for CIMPPs to avoid or minimize impacts on these types of resources, such as traditional plant gathering and offering areas or sacred viewsheds. **BIA:** Setbacks for CIMPPs would limit potential direct and indirect impacts, when compared with the BIA No Action Alternative; however, the lack of stipulation related to dark skies and Yádiłhił could affect certain CIMPPs.	**BLM:** Similar impacts described under the No Action Alternative and Alternative A would occur; however, each of the sub-alternatives would result in the fewest impacts because the least amount of area would be open to leasing. There would also be a 10-mile no leasing zone around the CCNHP under Alternative B1 and, under Alternative B2, a 15-mile no leasing zone around the CCNHP and corresponding no leasing zones around the Chacoan outliers of Pueblo Pintado and Kin Bineola under both sub-alternatives. **BIA:** Similar to Alternative A; however, in addition, stipulations and COAs to limit light pollution at certain locations, including some CIMPPs, could limit impacts on dark skies and Yádiłhił.	**BLM:** This alternative would include vegetation treatments focused on managing for traditional plant uses and CIMPPs, which would result in fewer impacts on CIMPPs and ITAs, compared with the No Action Alternative. They also would reduce indirect visual, noise, and vibration impacts that could diminish aspects of historic integrity, such as setting or feeling. NSO stipulations under Sub-Alternatives C1-C5 and a leasing closure under Sub Alternative C6, for various distances up to 10 miles around CCNHP and the boundaries of Pueblo Pintado and Kin Bineola; would reduce impacts on CCNHP when compared to the No Action Alternative. **BIA:** Similar to the No Action Alternative, except stipulations and COAs to limit noise and light pollution at CIMPPs could reduce direct and indirect impacts on CIMPPs and Yádiłhił.	**BLM:** Direct and indirect impacts under this alternative would be similar to those under the No Action Alternative, as the same area of land would be open to leasing. **BIA:** Similar to Alternative C.
Paleontological Resources	**BLM:** Direct and indirect impacts on paleontological resources would result from shallow ground-disturbing activities that could expose and destroy surface and near-surface fossils, as well as from increased access; this could lead to vandalism, unauthorized collection, or inadvertent damage or loss. Direct impacts could occur with each phase of fluid mineral exploration and development after leasing and the APD. **BIA:** Lessees would continue to submit NEPA compliance documentation to the BIA or FIMO, as applicable, before entering leased land or disturbing the ground surface; however, certain impacts, as described, above could still occur.	**BLM:** Potential impacts would be similar to those of the No Action Alternative; however, closing areas to leasing and restricting surface disturbance would minimize potential impacts on paleontological resources. **BIA:** The potential for impacts on paleontological resources would be similar to those of the No Action Alternative. This alternative would have requirements to reduce surface disturbance by collocating infrastructure. this would minimize surface disturbances and reduce the potential for impacts on paleontological resources.	**BLM:** Vegetation treatments and lands with wilderness characteristics management would be the same under this alternative and sub-alternatives as under Alternative A; however, the fewest acres would be available for leasing under this alternative; accordingly, impacts would be the fewest under this alternative. **BIA:** The potential for impacts on paleontological resources would be similar to that of Alternative A, but it would include the authority to minimize additional surface disturbance through collocation. This would reduce the potential for impacts from direct ground disturbance, erosion, and access.	**BLM:** The areas open and closed to fluid mineral leasing under Alternative C and sub-alternatives C1 through C5 are the same as those under the No Action Alternative, while under sub-alternative C6 there would be a slight reduction; thus, the types of impacts would be similar to those described under the No Action Alternative. **BIA:** The potential for impacts on paleontological resources would be the same as those under Alternative B	**BLM:** Impacts would the same as those under the No Action Alternative. **BIA:** The potential for impacts on paleontological resources would be the same as those under Alternative B

Resource Affected	No Action Alternative	Alternative A	Alternative B (Includes BLM Sub-Alternatives B1 and B2)	Alternative C (Includes BLM Sub-Alternatives C1-C6)	Alternative D
Noise Resources	**BLM:** Direct and indirect impacts on noise resources would occur on a long- and short-term basis and would result both in areas of fluid mineral leasing and in areas next to leasing activity. Noise from initial well construction and later ongoing well pad activity would increase the noise level in these areas. Because this alternative allows for the most unrestricted leasing, such impacts would be the greatest here. **BIA:** Under a continuation of current management, there would be no specific noise-related stipulations. Impacts would be similar to those described above.	**BLM:** Impacts would be similar to those described under the No Action Alternative; however, because a greater area would be closed to leasing and because NSO, CSU, AND TL stipulations would apply, overall impacts would be reduced. **BIA:** Management and associated impacts would be similar to those described above.	**BLM:** Impacts would be similar to those described under the No Action Alternative; the greatest area would be closed to leasing and the largest amount of NSO, CSU, and TL stipulations would apply. Because of this, the overall impacts would be reduced to the greatest degree. **BIA:** Management and associated impacts would be similar to those described above.	**BLM:** Noise impacts under alternative C and sub-alternatives C1 through C5 would be the same as those under the No Action Alternative. Under sub-alternative C6, closing more acres to fluid mineral leasing, compared with the No Action Alternative, would reduce the potential for noise impacts from fluid mineral activity. **BIA:** Management and associated impacts would be similar to those described under Alternative B.	**BLM:** Impacts would the same as those under the No Action Alternative. **BIA:** Management and associated impacts would be similar to those under Alternative B.
Visual Resources	**BLM and BIA:** No visual impacts would occur, beyond what is analyzed in the 2003 RMP and 2014 Visual Assessment.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.
Lands and Realty	**BLM:** ROWs would continue to be managed on a case-by-case basis, and there would be few limitations on the placement of new ROWs throughout the decision area. This would accommodate demand for new ROWs associated with energy and mineral development in the decision area. **BIA:** Impacts would be similar to those described above.	**BLM:** Under Alternative A, ROWs would be excluded in certain areas. In other areas, the placement of new ROWs would be subject to special siting criteria, design requirements, or other constraints to minimize resource impacts. This could limit or preclude new ROW development in those areas. **BIA:** There would be fewer impacts than those described under the No Action Alternative because there would be fewer locations where new ROWs could be developed.	**BLM:** Alternative B and sub-alternatives would result in similar impacts as under BLM Alternative A, but fewer areas would be available for ROW development. **BIA:** Same as Alternative A.	**BLM:** Under this alternative and sub-alternatives C1 through C6, ROW placement would be excluded or avoided in fewer areas than under Alternatives A and B; thus, it would result in similar opportunities for the placement of new infrastructure as the No Action Alternative. **BIA:** Same as Alternative A.	**BLM:** Impacts would be the same as those under Alternative C. **BIA:** Same as Alternative A.
Livestock Grazing	**BLM and BIA:** There would be no impacts on grazing on lands in the decision area from this RMPA, beyond what is analyzed in the 2003 RMP. Fluid mineral leasing and development in the BIA mineral decision area would continue, with the potential for direct and indirect impacts on livestock grazing operations.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.
Lands with Wilderness Characteristics	**BLM:** There would be no lands managed to protect their wilderness characteristics as a priority over other multiple uses. This would leave these lands vulnerable to direct and indirect impacts from surface-disturbing activities. This would diminish wilderness characteristics over the short and long term, by altering the natural setting, and would reduce opportunities for solitude or primitive recreation. **BIA:** No similar action under the BIA alternatives.	**BLM:** All four lands with wilderness characteristics units would be managed as closed to fluid mineral leasing, and more acres would be managed as ACECs than under all other alternatives. This would provide more protection than all other alternatives for wilderness characteristics in these areas by reducing or eliminating surface-disturbing activities. **BIA:** See the No Action Alternative.	**BLM:** Impacts would be the same as those under Alternative A. **BIA:** See the No Action Alternative.	**BLM:** No lands would be managed to protect their wilderness characteristics; therefore, impacts would be similar to those under the No Action Alternative but slightly less in magnitude, due to more acres being managed as ROW avoidance or exclusion. **BIA:** See the No Action Alternative.	**BLM:** Same as under Alternative C. **BIA:** See the No Action Alternative.
Wilderness and Wilderness Study Areas	**BLM and BIA:** There would be no impacts on wilderness areas or WSAs.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.

Resource Affected	No Action Alternative	Alternative A	Alternative B (Includes BLM Sub-Alternatives B1 and B2)	Alternative C (Includes BLM Sub-Alternatives C1-C6)	Alternative D
Specially Designated Areas	**BLM and BIA:** There would be no impacts on ACECs or their relevant and important values.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.
Socioeconomic Resources	**BLM:** Oil and gas development in the planning area would continue to support area employment, income, and economic contributions and could affect quality of life, property values, other land uses, and nonmarket values. Total economic output from drilling, completion, and production of federal minerals is estimated to be $461,688,100 at year 1 of plan implementation. **BIA:** Social and economic impacts would continue to occur as they currently do under existing BIA management. Total economic output from drilling, completion, and production of Tribal trust and Indian allotted wells is estimated to be $108,391,089 at year 1 of plan implementation.	**BLM:** Economic impacts would be the fewest, and there would also be the least potential for impacts on nonmarket values; values such as recreation, wilderness characteristics, wildlife, and ecological processes would be preserved. **BIA:** Similar to that described under the No Action Alternative, but economic impacts on allottees, lessees, and operators could be increased under Alternative A. This is because there would be more enforceable regulations at the lease, drilling, and operation stages of development.	**BLM:** Economic impacts would be reduced. Total economic output would be less than under the No Action Alternative at year 1 of plan implementation. There would also be less potential for impacts on nonmarket values, such as recreation, wilderness characteristics, and cultural resources. Also, the traditional social setting would be preserved. **BIA:** Same as under Alternative A.	**BLM:** Total economic output would be slightly less than under the No Action Alternative at year 1 of plan implementation. There would also be a slightly reduced potential for impacts on nonmarket values. Values such as recreation, quality of life, and the traditional social setting would be preserved, while economic development opportunities would be only slightly diminished. **BIA:** Same as under Alternative A.	**BLM:** Total economic output from drilling, completion, and production of federal minerals is estimated to be the same as under the No Action Alternative. There would also be the greatest potential for continued impacts on nonmarket values. **BIA:** Same as under Alternative A.
Environmental Justice	**BLM:** The types of impacts on environmental justice populations would be the same as those described in other resource analyses in this RMPA for the general population. The specific extent of impacts on identified environmental justice populations would be identified in future site-specific NEPA analyses. **BIA:** Impacts that would be incurred by the general population under the No Action Alternative would also be impacts on environmental justice populations. There also could be human health and safety impacts on individual Indian allotment lessors. The specific extent of impacts on identified environmental justice populations would be identified in future site-specific NEPA analyses	**BLM:** Similar to the No Action Alternative. The specific extent of impacts on identified environmental justice populations would be identified in future site-specific NEPA analyses. **BIA:** Similar to the No Action Alternative, but there could be additional impacts on the lessor to obtain an alternative or commercial energy source and new or additional monetary compensation for Navajo surface landowners. The specific extent of impacts on identified environmental justice populations would be identified in future site-specific NEPA analyses.	**BLM:** The least potential exists for impacts on environmental justice populations. The specific extent of impacts on identified environmental justice populations would be identified in future site-specific NEPA analyses. **BIA:** Same as Alternative A.	**BLM:** The amount of area under this alternative and each sub-alternative that is subject to surface occupancy stipulations or closures corresponds to the degree of potential impacts on environmental justice populations. The specific extent of impacts on identified environmental justice populations would be identified in future site-specific NEPA analyses. **BIA:** Same as Alternative A.	**BLM:** Same as the No Action Alternative. **BIA:** Same as Alternative A.
Recreation	**BLM and BIA:** There are no decisions being made that would make changes to recreation areas and visitor services in the planning area. Hunting, fishing, and recreational shooting will not be affected by this RMPA/EIS. Designated recreation areas would continue to be managed as they are currently through the 2003 RMP.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.	See the No Action Alternative.

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Appendix G

Farmington Field Office Vegetation Communities Descriptions and Determination of Farmington Field Office Vegetation Condition Classes

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TABLES

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations	Full Phrase
BLM	United States, Department of the Interior, Bureau of Land Management
DPC	desired plant community
ESD	ecological site description
FFO	Farmington Field Office
HCPC	historic climax plant community
LRR	land resource region
MLRA	major land resource area
NRCS	Natural Resources Conservation Service
PFC	proper functioning condition
PNPC	potential natural plant community
RHA	rangeland health assessment
STM	state-and-transition model
SWReGAP	Southwest Regional Gap Analysis Project
TCP	traditional cultural property
T&E	threatened and endangered
USDA	United States Department of Agriculture
VCC	vegetation condition class
VDEP	vegetation departure

Appendix G. Farmington Field Office Vegetation Communities Descriptions and Determination of Farmington Field Office Vegetation Condition Classes

The BLM FFO has created this document to describe in detail the developed FFO broad-scale vegetation communities, and proposed FFO-VCCs.

G.1 FFO Vegetation Community Descriptions

G.1.1 Background

The BLM FFO developed broad-scale vegetation community descriptions through combined vegetation resource datasets and staff knowledge. The descriptions below present an overview of nine (9) FFO broad-scale vegetation communities. Datasets for development include the USDA NRCS ecological site descriptions (ESDs) and Southwest Regional Gap Analysis Project (SWReGAP) data. These 9 vegetation communities include pinyon-juniper, sagebrush grassland, grassland, badlands, saltbush/shadscale, greasewood, riparian, oak woodlands and ponderosa pine-mixed conifer. Seven (7) vegetation communities are described in detail. Oak woodlands and ponderosa pine-mixed conifer communities are not described in further detail as they comprise a minor percentage of the FFO vegetation community acreage. The badland and saltbush/shadscale communities are similar and are typically adjacent or mixed with each other; therefore, they have been combined for description purposes.

For these seven vegetation communities, selected ESDs for FFO vegetation communities were utilized to describe the averaged, general historic climax plant community (HCPC) or reference state potential vegetation percentages for above-ground production (expressed in pounds per acre) and/or cover (expressed in percentages) when data is available. ESD and HCPC definitions are described in detail further in this document under "FFO-VCCs". It must be emphasized that these ESDs are only discussed to provide general descriptions for the overall larger community in which they are categorized. The actual ESDs for specific sites within the vegetation community may include different values from these general presented averages. ESDs are also strongly associated with NRCS soil survey types. ESDs are periodically updated and may contain State-and-Transition models and updated values from those described in this document. The ESDs described in this document were existing in 2015. It should be emphasized that these ESDs may change with time, and the best available data should be utilized and incorporated in the future.

The following **Table G-1** summarizes the SWReGAP mapped vegetation types and ESDs utilized for evaluation in this document.

Table G-1
FFO Broad-scale Vegetation Communities with Associated Mapped SWReGAP Vegetation Types and ESDs Utilized for Evaluation

FFO Vegetation Community	SWReGAP Vegetation Types	ESDs Utilized for Evaluation
Pinyon-juniper	Southern Rocky Mountain Montane – Subalpine, Colorado Plateau Pinyon-Juniper Woodland, Colorado Plateau Mixed Bedrock-Pinyon/Juniper Rock Outcrop, Southern Rocky Mountain Pinyon-Juniper Woodland	Sandstone Upland 13-17" p.z. (JUOS, PIED) R035XF627AZ, Sandy Loam Upland 13-17" p.z. (JUOS, PIED) F035XF628AZ)
Sagebrush Grassland	Intermountain Basins Semi Desert Shrub Steppe, Intermountain Basins Big Sagebrush, Colorado Plateau Mixed Low Sagebrush Shrubland	Loamy R035XB001NM, Sandy R035XB002NM, Shallow R035XB006NM, Limy R035XB003NM, Deep Sand R035XB007NM, Loamy R036XB006NM, Loamy Savanna R036XB016NM, Sandy R036XB011NM, Stony Loam R036XB018NM
Grassland	Intermountain Basins Semi Desert Grassland	(Clay Loam Terrace (sodic) 7-10" R035XB016NM, Loamy Upland 7-10" R035XB021NM, Loamy Upland sodic R035XB022NM, Saline Bottom 6-10" R035XB024NM, Sandy Loam Upland 6-10" R035XB030NM, Sandy Loam Upland 6-10" sodic R035XB033NM, Loamy 6-10" terrace R035XB020NM, Sandy Terrace 6-10" sodic R035XB034NM, Sandy Upland 6-10" R035XB035NM)
Badland	Intermountain Basins Shale Badland, Colorado Plateau Mixed Bedrock Canyon and Tableland, Rocky Mountain Cliff and Canyon	Mudstone/Sandstone Hills 6-10" p.z. R035XB201AZ, Clayey R035XB004NM, Clayey R035XA128NM, Shale Hills 6-10" p.z. R035XB268AZ, Clayey R036XB002NM
Saltbush/shadscale/ winterfat	Southern Colorado Plateau Sand Shrubland, Colorado Plateau Blackbrush Mormon Tea, Invasive Annual and Biennial Forkland	
Greasewood	Intermountain Basins Greasewood Flat, Intermountain Basins Mixed Salt Desert Scrub	Salt Flats R035XA126NM, Salt Flats R035XB005NM, Sodic Slopes R035XB008NM, Salty Bottomland R036XB010NM, Saline Bottom 6-10" R035XB024NM
Riparian	Rocky Mountain Lower Montane Riparian Woodlands, North American Arid West Emergent Wash, Invasive Southwest Riparian Woodland and Shrubland, Rocky Mountain Aspen Forest and Woodland	Loamy Bottom 6-10" p.z. Perennial (Provisional) R035XB269AZ, Sandy Bottom 6-10" p.z. Perennial (Provisional): R035XB273AZ
Oak Woodlands	Rocky Mountain Gamble Oak-Mixed Montane Shrubland, Rocky Mountain Lower Montane – Foothill Shrubland	
Ponderosa Pine-Mixed Conifer	Rocky Mountain Ponderosa Pine Woodland, Rocky Mountain Montane Mesic Mixed Conifer Forest & Woodland, Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest & Woodland	

The following **Table G-2** lists common perennial grasses, shrubs, and trees that are found in each vegetation community, with the exclusion of riparian areas. Riparian vegetation is unique from upland vegetation and is therefore described separately in detail in Chapter 3.

Table G-2
Common Grass, Shrub, and Tree Species by General FFO Vegetation Communities, with the Exception of Riparian

Rangeland Plant	Scientific Name	Pinyon-Juniper	Sagebrush Grassland	Grassland	Badland & Saltbush/ Shadscale	Greasewood	Oak Woodlands	Ponderosa Pine-Mixed Conifer
Grass								
Western wheatgrass	*Pascopyrum smithii*	X	X			X	X	X
Indian ricegrass	*Achnatherum hymenoides*	X	X	X	X	X	X	
Needleandthread	*Hesperostipa comata*	X	X	X				
Bottlebrush squirreltail	*Elymus elymoides*	X	X	X	X	X		X
Galleta	*Pleuraphis jamesii*		X	X	X	X	X	
Blue grama	*Bouteloua gracilis*	X	X	X		X	X	X
Alkali sacaton	*Sporobolus airoides*			X	X	X		
Sand dropseed	*Sporobolus cryptandrus*	X	X		X	X		
Purple threeawn	*Aristida spp.*			X				
Muhly	*Muhlenbergia spp.*			X				
Muttongrass	*Poa fendleriana*	X					X	X
Prairie junegrass	*Koeleria macrantha*	X					X	X
Slender wheatgrass	*Elymus trachycaulus*					X	X	
Arizona fescue	*Festuca arizonica*						X	X
Forbs								
Small burnet								
Blue flax								
Gooseberry leaf globemallow								
Palmer penstemon								
Rocky mountain bee plant								
Asclepias arenaria, Asclepias asperula, Asclepias cutleri, Asclepias fascicularis, Asclepias involucrata, Asclepias latifolia, Asclepias macrotis, Asclepias rusbyi, Asclepias ruthiae, Asclepias sanjuanensis, Asclepias speciosa, Asclepias subverticillata, Asclepias viridiflora								
Shrub								
Big sagebrush	*Artemisia tridentata*		X		X	X	X	
Antelope bitter brush								
Fourwing saltbush	*Atriplex canescens*		X		X	X		

Rangeland Plant	Scientific Name	Pinyon-Juniper	Sagebrush Grassland	Grassland	Badland & Saltbush/ Shadscale	Greasewood	Oak Woodlands	Ponderosa Pine-Mixed Conifer
Mountain Mahogany								
Winterfat	*Krascheninnikovia lanata*		X		X	X		
Broom snakeweed	*Gutierrezia sarothrae*			X	X			
Rabbitbrush	*Chrysothamnus spp.*					X		
Black greasewood	*Sarcobatus vermiculatus*			X		X		
Rabbitbrush			X	X		X		
Shadscale	*Atriplex confertifolia*				X	X		
Alder leaf mountain mahogany	*Cercocarpus montanus*	X					X	X
Antelope bitterbrush	*Purshia tridentata*		X				X	X
Skunkbush sumac	*Rhus trilobata*	X						
Utah serviceberry	*Amelanchier utahensis*	X					X	X
Black sagebrush	*Artemisia nova*	X						
Mound saltbush	*Atriplex obovata*			X				
Ephedra	*Ephedra spp.*			X	X	X		
Trees								
Utah juniper	*Juniperus osteosperma*	X			X		X	
Colorado pinyon	*Pinus edulis*	X			X		X	X
Gambel's oak	*Quercus gambelii*	X					X	X
Rocky Mountain Juniper	*Juniperus scopulorum*	X						X
Ponderosa pine	*Pinus ponderosa*						X	X

Additionally, forbs are variable across the vegetation communities, and include both perennials and annuals. Common important forbs include scarlet globemallow (*Sphaeralcea coccinea*), biscuit root (*Lomatium spp.*), woolly plantain (*Plantago patagonica*), astragalus spp. (*Astragalus spp.*), and asters (*Aster spp.*), among others.

For the seven communities described in detail, a community general description, health indicators, importance, and threats are discussed. For all vegetation community types, common quantitative and qualitative indicators and assessment methods are utilized to assess ecosystem health. These are described in further detail under "FFO Vegetation Condition Classes". Present plant species composition, cover, and abundance and their level of departure from reference conditions is an important indicator in all communities. There are also common threats to all FFO vegetation communities. These common threats include decreased biodiversity, noxious and nonnative invasive species (weed) invasion, climate fluctuation impacts such as drought, any improper grazing use by domestic and free-ranging animals, and fragmentation associated with oil and gas development, rights-of ways, cross-country travel, and community (urban) development. Threats unique or important to each community are discussed in their respective sections. Regarding importance, all communities provide wildlife habitat and/or domesticated livestock forage to varying degrees.

G.1.2 Pinyon-Juniper

Description

The pinyon–juniper community comprises a large percentage of the total BLM FFO-managed landscape. Pinyon trees dominate at higher elevations and tend to form more closed-canopied stands that exhibit forest-like dynamics and species composition, commonly including a substantial shrub component. Juniper tends to grow at lower elevations and in more arid areas. There is a mix of warm and cool season grass species, mostly bunch grass species within varying elevations of pinyon-juniper communities. At higher elevations or north facing aspects other shrubs and trees species may be present.

Soils are variable, ranging from relatively deep soils often high in clay or sand content, to shallow rocky soils. The community can also be found in rock outcrops where no soil is present, but the trees are rooted in deep cracks of the bedrock. Woodlands of pinyon or juniper occupy a broad zone of intermediate moisture and temperature conditions between the lower elevation hot arid deserts and higher elevation cool mesic (moisture) forests. The FFO pinyon-juniper community can be further described as either persistent pinyon-juniper woodlands or wooded shrublands.

Persistent pinyon–juniper woodlands are typically found on rugged uplands in shallow rocky soils, can have tree canopies dominated by either or both pinyon and juniper, and typically have sparse understories with extensive areas of litter (beneath canopies) and bare soil or rock (intercanopy). In comparison to persistent woodlands, wooded shrublands are typically found on deeper soils, may have less dominant tree cover canopies, and typically have higher understory canopy cover and production.

Various ESDs occur within the pinyon-juniper vegetation community. The two ESDs with pinyon and juniper trees as major components listed in **Table G-1** provide a general description of persistent pinyon-juniper woodlands (shallow, rocky soils) or wooded shrublands (deeper soils), providing that other ESDs within this community exist.

Sandstone Upland 13-17" p.z. (JUOS, PIED) F035XF627AZ contains the characteristics associated more closely with the persistent pinyon-juniper woodlands (shallow, rocky soils) vegetation type. This ESD states that for the reference state, the tree overstory canopy cover is typically 40-50% within a range of 25 to 65% cover, and that the understory composition is approximately 20% shorter trees below 4.5 feet (') high, 55% shrubs, 20% grasses and 5% forbs. *Sandy Loam Upland 13-17" p.z. (JUOS, PIED) F035XF628AZ* contains the characteristics associated more characteristic of the pinyon-juniper wooded shrublands (deeper soils) vegetation type. This ESD state that for the reference state, the tree overstory canopy cover is typically 50-60% with a composition of approximately 50% to 80% pinyon and 20% to 50% juniper, and that the understory composition is approximately 10% shorter trees below 4.5' high, 30 to 40% shrubs, and 30% to 50% grasses.

Indicators

Important pinyon-juniper health indicators include intactness (ecological integrity), patch size for wildlife use, and obligate wildlife species. Pinyon-juniper community soils are often very erosive; therefore, biological soil crust amount and cover, bare ground amount, and active erosion evidence are important.

Stand (group of trees) dynamics many be driven by climatic fluctuation such as drought, insects, disease, and wildfire. For example, a widespread and severe pinyon mortality event occurred in 2002–2004 in the Four Corners region (Colorado, Arizona, New Mexico, and Utah) as a result of drought, high temperatures, and bark beetle outbreaks. Fire may be a less influencing factor. Fire rotations and intervals vary, but typically were historically long (generally measured in centuries). Recent, large, severe (stand-replacing) fires in pinyon and juniper woodlands are, for the most part, similar to fires that occurred historically. Tree density and canopy coverage has varied over areas, as well as expansion into neighboring vegetation communities.

Importance

The pinyon-juniper community provides thermal cover, mast, and migration corridors for large game, prey, and other wildlife species. These woodlands are utilized by a BLM Sensitive Species, the pinyon jay (*Gymnorhinus cyanocephalus*). Pinyon jays nest colonially within mature stands of pinyon and juniper trees.

This community also provides habitat for cavity nesting birds and nesting substrate, perching, and roosting for birds and raptors. This habitat type is culturally significant to the local community for aesthetics, older trees, wood and pine nut gathering, and other traditional uses such as hunting.

Threats

Insect infestations such as the pinyon Ips beetles (*Ips confusus*), climate fluctuation, and disease can cause widespread pinyon and juniper mortality. Fire regime and condition class changes and departures from reference conditions can be a threat. Fuel wood-cutting and its associated impacts of cross-country travel is a very widespread practice in the FFO and threatens the pinyon-juniper community, particularly in areas near communities and urban areas. Fragmentation associated with oil and gas development, rights-of ways, and cross-country travel can also affect intactness. Past historical vegetation treatments such as chainings have been performed on the pinyon-juniper community to reduce the amount and density of trees; some treatments have been successful, while others may not have been properly maintained.

G.1.3 Sagebrush Grassland

Description

The sagebrush grassland vegetation community is a dominant component of the FFO area landscape. The community is comprised primarily of Wyoming big sagebrush and grasses. This plant community occupies vast areas of relatively open rolling hills to the south of Farmington and numerous mesas and canyon bottoms to the east and north. It is found on all aspects from about 5,000 to 7,200' but is most common on southerly and western aspects. Soils vary from clayey to fine sandy loam to loamy in texture with loamy sites being more pervasive. In general, the soils underlying this plant community are moderately deep and well drained.

This community is also integral to a proper functioning watershed and ecosystem. Maintaining proper hydrologic function of this plant community is essential to the ability of the plants to produce forage for livestock and wildlife, retention of soils on site and the minimization of the degradation of water quality due to the deposition of salts and sediment.

At the broad-scale level, the SWReGAP land cover mapped vegetation types of intermountain basins semi-desert shrub steppe, intermountain basins big sagebrush, and Colorado Plateau mixed low sagebrush shrubland. They comprise the sagebrush grassland community.

The annual production (lbs. /ac.) for the ESDs reviewed in **Table G-1** only presented shrub production in two (*Shallow R035XB006NM*) and *Loamy R036XB006NM*). Calculated composition by production can be used to make a very general average of the sagebrush grassland community composition as having approximately 74-75% grass/grass-like, 8-10% forb, and 15-18% shrub components of total HCPC potential average annual production (lbs./ac).

For ground cover, the percent bare ground (%) for the ESDs reviewed did include an outlier of 10% on one site (*Gravelly Fan R036XB003NM*), but the remainder of the ESDs ranged from approximately 42%-65%, with approximately 50% bare ground being the average. Higher percentages of bare ground are typically allowed in the lower elevation/lower precipitation areas. The percent non-vegetative litter cover (%) ranged from 10-20%, with approximately 14% as the average across all ESDs. It must be noted that the values utilized vary for individual ESDs.

Indicators

Some of these specific indicators were determined to be more important for the sagebrush grassland community and can also be used to assess the health of sagebrush grassland communities. Ecological succession is a strong indicator in this community as density of sagebrush cover increases with successional stages. Regarding succession, debate exists regarding the level of sagebrush cover and percent composition as well as other species required in this community for livestock use, wildlife use, and watershed function. As in all vegetation communities, species composition in comparison to the vegetation composition expected in ESDs is important. Particularly in the sagebrush grassland in the FFO, a change in the expected proportion of cool-season and warm-season grasses is an important indicator.

Plant species composition relative to importance for wildlife is also critical. Patch size for wildlife habitat relative to habitat fragmentation in the sagebrush grassland community as well as the presence or absence of obligate species to this community can help indicate its health.

Importance

Because the sagebrush grassland vegetation community is extensive across the FFO and is productive for forage, it is very important to wildlife and domestic livestock for food and protective shelter.

Permitted domestic livestock that utilize the sagebrush grassland community include cattle and sheep, and occasionally goats and horses. The sagebrush grassland community is arguably the most commonly used vegetation community for domestic livestock grazing within the FFO. The majority of permitted livestock grazing in this community occurs in the fall and winter, with a lesser number of spring/summer growing season or year-long grazing schedules. Most individual ESDs contain descriptions of plant preference by livestock animal kind as well as guides to suggested initial stocking rate acres per AUM based on similarity indexes to the reference plant community. For plant species within the sagebrush grassland, it is important to maintain proper utilization levels for both livestock and wildlife at overall conservative (31-40% use) to moderate (41-50%) use levels depending on conditions.

Two important BLM Sensitive Species utilizes this vegetation community, Gunnison's prairie dog (*Cynomys gunnisoni*) and Western burrowing owl (*Athene cunicularia ssp. hypugaea*). Prairie dog towns are often found within sagebrush communities. Prairie dog holes provide important nesting habitat for burrowing owls. This community provides habitat (including nesting), cover, and biodiversity. Wildlife in the FFO includes a variety of sagebrush obligate bird species and small mammals, as well as large ungulates such as mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), and pronghorn (*Antilocapra americana*). This community also provides wildlife migratory stop-over areas and transition habitat between other vegetation communities, such as between riparian or bottom land areas and forested areas like pinyon-juniper communities. Sagebrush grassland communities also serve as large ungulate fawning areas and provide critical wintering range. In this community, large ungulates may utilize palatable grasses (both warm- and cool-season), forbs, and shrubs all year, or change preference with seasonal changes. Palatable shrubs are an important component of large ungulate diets.

The sagebrush grassland community as an upland vegetation community is critical for watershed health, particularly in helping lessen erosion in nearby-occurring communities such as riparian areas. Its perennial grass component serves to stabilize soil and facilitate water infiltration. The sagebrush grassland community has undergone vegetation treatments in many areas to restore the grassland component and the watershed and vegetative function of areas, primarily by reducing late ecological successional stage shrub density. The majority of these vegetation treatments have been through herbicide (chemical) tebuthiuron application, but other treatments have included such methods as mowing, Dixie harrowing, prescribed fire, and historic chainings.

There are also other human use components of the sagebrush grassland community within the FFO aside from domestic livestock grazing. TCP areas exist within the sagebrush grassland community, and some of the plant species found within the sagebrush grassland are used traditionally. Furthermore, the area is often used for various recreational uses and for development, including oil and gas and urban growth.

Threats

As with most vegetation communities, drought and potential climatic changes are environmental threats to the sagebrush grassland community. Drought has led and may potentially continue leading to reduced perennial native vegetation growth and reproduction throughout the FFO, as well as desirable annuals. Disturbances, however they are caused, that lead to a lack of native perennial grass cover and increased bare ground can also lead to increases in non-native or invasive species, particularly cheatgrass (*Bromus tectorum*).

This community can also potentially be impaired by inappropriately managed livestock grazing, both historic and current. This primarily has occurred through over-utilization of key plant species. However, overutilization is not limited to livestock, as wildlife can also over-utilize key plant species. Trespass or feral livestock such as unauthorized excess horses have also been noted to threaten the sagebrush grassland community in the FFO by consuming forage not allocated to them. While debate exists over the frequency of fire and its role in the sagebrush grassland community, its suppression may have an impact on the present-day existing vegetation.

Factors such as historic grazing, fire suppression, or past vegetation treatments can also lead to a decrease in biodiversity and seral stages. Ecological succession into late seral stages is desirable for some management objectives but can also threaten the community by leading to a reduction in perennial grass understory from increased shrub cover.

While each individual ESD typically describes the deterioration of the potential plant community, in general the ESDs note that inappropriate grazing use leads to a decline in perennial grasses (often cool-season grasses) and palatable forbs and shrubs (such as fourwing saltbush) and an increase in less desirable and less palatable grasses (often warm-season grasses) and an increase in less palatable shrubs (such as sagebrush – on which its palatability is dependent on the animal species browsing it - and broom snakeweed). A decline in perennial grass cover can also lead to soil degradation and erosion issues and impair water infiltration into the soil.

G.1.4 Grassland

Description

This plant community occurs primarily in the southern FFO landscape within the BIA Eastern Navajo Agency or "Checkerboard" area of mixed land jurisdiction along the boundary of the Navajo Nation. The grassland community is dominated by perennial grasses, with a lesser shrub component primarily dominated by saltbushes. It is found on all aspects from about 4,700 to 6,400', generally with little slope. Soils vary from clay loam and sandy loams, with generally deep and well drained underlying soils. Some soils are more sodic than others, and salt concentrations vary with the amount and timing of precipitation and affect the growth of certain plant species. Maintaining proper hydrologic function of this plant community is essential to the ability of the plants to produce forage for livestock and wildlife, retention of soils on site, and the minimization of the degradation of water quality from salts and sediment deposition.

At the broad-scale level, the SWReGAP land cover mapped vegetation types of intermountain basins semi-desert grassland to create the grassland community.

The annual production (lbs. /ac.) was presented in all reviewed **Table G-1** ESDs with the exception of *Clay Loam Terrace (sodic) 7-10" R035XB016NM*. *Loamy Upland 7-10" R035XB021NM* was different from the other evaluated ESDs, and removing it from estimations results in grassland community ESDs averaging similarly to the sagebrush grassland ESDs. These can be used to make a very general average of the grassland community in the FFO as having approximately 77-81% grass/grass-like, 3-5% forb, and 16-18% shrub components of total HCPC potential average annual production (lbs./ac). It must be noted that the values utilized vary for ESDs. No cover values were discussed in any of the evaluated ESDs.

Indicators

These are the same as those for the sagebrush grassland community with the exception that ecological succession and subsequent shrub prevalence does not play as large a role as it does in the sagebrush grassland community. Also, because the soils in the grassland vegetation community generally have a severe wind erosion hazard, erosion is an important indicator.

Importance

The prevalence of the grassland vegetation community in the southern "Checkerboard" area of the FFO is productive for forage to both wildlife and domestic livestock with uses similar to the sagebrush grassland vegetation community.

Much of the grassland community is utilized for yearlong livestock grazing of primarily cattle and sheep, and occasionally goats and horses. Navajo community grazing permittees primarily utilize this vegetation community within the FFO. Overall grazing use in the FFO is the same as that for the sagebrush grassland community, with the primary difference that most of the grazing in the grassland community is yearlong, whereas it is typically seasonal in the sagebrush grassland community.

The same wildlife as the sagebrush grassland utilize this community for habitat (including nesting), cover, and biodiversity. Mountain plover (*Charadrius montanus*) nesting habitat can also be found in it.

There are other human use components of the grassland community within the FFO aside from domestic livestock grazing. TCP areas exist within the grassland community, and some of the plant species found within the grassland are used traditionally. The area can be used for various recreational uses and for development, including oil and gas and urban growth. However, much less oil and gas development has occurred in this vegetation community than has occurred in other vegetation communities within the FFO.

Threats

Soils in the grassland vegetation community generally have a severe wind erosion hazard, and with site deterioration, erosion occurs on overgrazed area, roads, livestock trails, and concentration areas.

As with most vegetation communities, drought and climatic change are also environmental threats to the grassland community. Drought has led to and may potentially continue leading to reduced perennial native vegetation growth and reproduction throughout the FFO, as well as undesirable annuals. Drought may also lead to temporary annual livestock reductions in some grazing allotments in this vegetation community across the FFO. While they are not as extensive as those in the sagebrush grassland community in the FFO, disturbances and fragmentation can alter this community and introduce non-native and invasive species. Erosion can increase from this, and cause such issues as blowing dust and sedimentation of adjacent areas.

Like the sagebrush grassland community, the grassland community can also potentially be impaired by inappropriately managed livestock grazing, both historic and current. Trespass or feral livestock such as unauthorized excess horses have also been noted to threaten the grassland community in the FFO as well as the sagebrush grassland community through consuming forage not allocated to them. Any permanent reduction in livestock grazing based on historic use is evaluated and determined based on range inventory and long-term monitoring data.

Fires are historically frequent in this community and have an important role. Factors such as historic grazing and fire suppression can also lead to a decrease in biodiversity and seral stages. However, succession is typically less of a threat in the grassland community than it is in the sagebrush grassland community in the FFO. There have been few to no vegetation treatments conducted by the FFO in this vegetation community as over-dominance of shrubs due to succession – which can occur in the sagebrush grassland community - does not occur prevalently in the grassland community in the FFO.

While each individual ESD typically describes the deterioration of the potential plant community, in general the ESDs note that inappropriate grazing use or deterioration of the site leads to a decline in perennial grasses (often cool-season grasses) and an increase in less desirable and less palatable grasses (often annuals), annual weeds, and an increase in less palatable shrubs. A decline in perennial grass cover can also lead to soil degradation and erosion issues and impair water infiltration into the soil.

G.1.5 Badland and Saltbush/Shadscale/Winterfat

Description

The badland community comprises a relatively small but important part of the total BLM-managed surface acres within the FFO. This community generally occurs at elevations ranging from approximately 4,800 to 7,000'. The general description for this site is that of a rough, broken badlands, sparsely vegetated, highly dissected and eroded into a series of low badland hills and gullies interspersed by somewhat sandy alluvial deposits. There is more of the surface area comprised of bare ground and rock than that which is vegetated. Large bare areas with only biological crust are not uncommon.

Plant communities of the badland complex are typically sparsely vegetated, often with less than 10% vegetation cover but occasionally up to 30%. Cryptobiotic soil/crust is an important component of this habitat. Shrubs and half shrubs are apparent and rather unevenly distributed. The potential plant community varies somewhat with depth of soil, exposure and slope. Despite the limited cover, these areas often support many endemic species. Many endemic species in NW New Mexico are restricted to soils derived from a specific geologic formation and most occur in areas of exposed parent materials.

An important component in maintaining site stability is perennial grasses, which should comprise at least 15 to 20 percent canopy cover. Shrub canopy cover depends on the soil type, but on average it should be approximately 10 percent. Forbs canopy would be highest in the spring, with a minimum of 5 percent cover.

Trees are relatively rare, except for on upper and moderately steep slopes, and generally consist of invading juniper trees. Common species, in addition to saltbush, shadscale and winterfat, are galleta, fourwing saltbush, Indian ricegrass, scarlet globemallow (Sphaeralcea coccinea), snakeweed, and mustard.

The saltbush/shadscale/winterfat communities comprise approximately minor component of BLM-managed surface area. Variability is evident within this cover type, so site specific criteria needs to be developed for treatment areas and planned project work. The soils associated with this cover type are typically sandy loam and sandy clay loam and are generally associated with mapping units in the Badland, Monierco, Persayo, Blancot, Notal, Avalon, Farb, and Fruitland soil complexes. These soils are susceptible to wind and water erosion without adequate herbaceous cover.

At the broad-scale level, the SWReGAP land cover grouped vegetation types of intermountain basins shale badland, Colorado Plateau mixed bedrock canyon and tableland, and Rocky Mountain cliff and canyon. They comprise the badlands community. The SWReGAP grouped vegetation types of southern Colorado Plateau sand shrubland, Colorado Plateau blackbrush Mormon tea, and invasive annual and biennial forkland. They comprise the saltbush/shadscale/winterfat community.

As previously stated, badlands and saltbush/shadscale/winterfat are associated communities in the FFO. While there is not a specific ESD for badlands the four **Table G-1** ESDs that can occur within both vegetation communities were evaluated. The annual production (lbs. /ac.) included shrub production in all **Table G-1** ESDs except *Shale Hills 6-10" p.z. R035XB268AZ. Mudstone/Sandstone Hills 6-10" p.z.*

R035XB201AZ is more representative of badlands, but may not specifically be found in the FFO as there is not a specific badlands ESD, but was used as a similar ESD to help describe the area.

While the *Mudstone/Sandstone Hills 6-10" p.z. R035XB201AZ* does not exactly reflect the badlands in the FFO, it and *Shale Hills 6-10" p.z. R035XB268AZ* show a difference in proportion of annual expected production (lbs.) between it and the other ESDs more representative of the saltbush/shadscale/winterfat community. This reflects that a higher shrub component is expected in the badland community than in the shadscale/winterfat community. These values can be used to make a very general average of the badland community in the FFO as having approximately 50% grass/grass-like and forbs (with the majority being forbs) and approximately 50% shrub components of total HCPC potential average annual production (lbs. /ac). Again, the badland and saltbush/shadscale/winterfat communities are closely associated, and the values from the Clayey ESDs may be used to make a very general average of the saltbush/shadscale/winterfat community in the FFO as having approximately 74-81% grass/grass-like, 7-8% forbs, and 11-19% shrub components of total HCPC potential average annual production (lbs./ac).

For ground cover, *Mudstone/Sandstone Hills 6-10" p.z. R035XB201AZ* which is more specific to badlands than saltbush/shadscale/winterfat lists non-vegetative expected cover as 20-40% bare ground and up to 40% surface fragments. For vegetation cover, this ESD lists 5-10% grass/grass-like, 0-5% forb, 5-15% shrub, and 0-1% tree as expected percentages. For the Clayey ESDs, the percent bare ground (%) for the ESDs ranged from approximately 10-20%, with approximately 15% bare ground being the average, which can be applied as a general approximate average across the saltbush/shadscale/winterfat and associated badland communities. It must be noted that the values utilized vary for individual ESDs.

Overall for these communities, an important component in maintaining site stability is perennial grasses which should comprise at least 15% to 20% canopy cover. Shrub canopy cover depends on the soil type but on average should be approximately 10%. Forbs canopy cover would be highest in the spring with a minimum of 5%.

Indicators

Some of these specific indicators were determined to be more important for the badlands community and can also be used to assess its health. The presence and proportion of fragile soils indicates the presence of badlands. Because of the fragile soils, the percentage of biological soil crusts and their percent cover is an important indicator. Furthermore, bare ground and the evidence of active erosion are also important indicators due to the soil fragility. For the saltbush/shadscale/winterfat community, erodible soils are also an important indicator as they are in the badland community. Shrubs are a major component of the saltbush/shadscale/winterfat community; therefore, shrub canopy cover is also an important indicator.

Importance

The importance of the badland vegetation community is indicated in the variety of other vegetation communities that it helps support, including saltbush/shadscale, sagebrush, juniper savanna, rock outcrops, and desert scrub type communities. The diversity of vegetation types support hundreds of different species of wildlife and rare plants, including two federally-listed plant species. Areas that appear bare and desolate can be abundant with wildlife. Additionally, there are also other resource values within the badland community, such as paleontological resources, recreational opportunities, scenic values, prey species (e.g., raptor hunting areas), cryptobiotic soils, relict plant communities (e.g., ponderosa pine trees), and cultural resources including traditional cultural properties and plant gathering sites.

Several important BLM Sensitive Species utilizes this vegetation community, including the Gunnison's prairie dog and Western burrowing owl similar to the sagebrush grassland and grassland communities. Four BLM Sensitive plant species habitat is endemic to badland, desert scrub/saltbush/shadscale soils. Clover's cactus (*Clerocactus cloverae ssp. brackii*) and Aztec gilia (*Aliciella formosa*) habitat is often found within badland community. The San Juan milkweed (*Asclepias sanjuanensis*) is associated with desert scrub sub-community and the Mancos saltbush (*Proatriplex pleiantha*) can be found in the saltbush/shadscale complex. Rock outcrops and cliffs within badland associated communities provides nesting and breeding habitat for a variety of raptor and small mammal species, as well as pronghorn.

For the shadscale saltbush/winterfat community, winterfat is an important forage plant for livestock and wildlife, especially during winter when forage is scarce (Blaisdell 1984). Winterfat is a staple food for jackrabbits, which are the primary food source for golden eagles (Anderson 1986). Several passerine bird species breed in winterfat-dominated communities; these include horned lark, Brewer's sparrow, sage thrasher, horned lark, black-throated sparrow, and loggerhead shrikes (Medin 1986).

Threats

The badland vegetation community is adapted to highly erodible soils that may be dry throughout the growing season. Generally, the plant communities will be drought tolerant, grazing resistant, and winter hardy, and will be tolerant of managed grazing practices or light-intensity fires. Because of the erodible soils, the shale badlands system is not tolerant of heavy use. The greatest threat to the badlands ecosystem is habitat damage or loss. This can occur from human activities, particularly activities related to energy development and associated infrastructure, invasive/noxious weed introduction and spread, habitat fragmentation, erosion, easier access to illegal OHV activity and other human activities (illegal hunting/woodcutting). Like other vegetation communities, drought and climate change can threaten the badland community, and the level of impacts is dependent on drought severity and length. Soil stability impacts due to drought include erosion and loss of organic material from drought-induced plant mortality. Soil compaction due to livestock trampling can also be a threat. Compaction reduces infiltration, available water capacity, aeration of plant roots, and habitat requirements for some soil organisms. Compaction can increase runoff, erosion, and resistance to plant root growth. Climate change can potentially threaten the badlands and other vegetation communities by potentially shifting the ranges of plant and animal species and biomes (major vegetation types), as well as altering the timing of events such as plant flowering and animal migration.

Threats to the saltbush/shadscale/winterfat community are similar to those for badland and sagebrush grassland communities. It is adapted to erodible soils that may be dry throughout the growing season. The greatest threat to the shadscale/saltbush/winterfat community is habitat loss from the aforementioned human actives described for the badland community. The aforementioned drought and climate change threats described for the badland community are also threats for the shadscale/saltbush/winterfat community. Past poor management practices such as overgrazing have reduced or eliminated winterfat within some shadscale/saltbush/winterfat communities in the FFO. Dominant species expected in the HCPC have been converted to tansymustard (*Descurainia spp*.) or have been invaded by the non-native and noxious species halogeton (*Halogeton glomeratus*) or Russian-thistle (*Salsola kali*).

G.1.6 Greasewood

Description

The greasewood vegetation community is predominately found in valley bottoms near riparian areas. These sites can potentially receive additional moisture from the adjacent uplands. Soils are generally deep, well drained and are sodium affected. The majority of these soils are fine sandy loams and silty clay loams. Soils in this vegetation type can contain inclusions that have elevated soluble salts (saline) properties and may require modification to treatment methods to ensure success, or may not be suitable for treatment at all. Root penetration can be restricted in shallower soils and by the sodium content. Vegetation can be difficult to establish in the finer clay soils; therefore, site specific criteria needs to be developed for treatment areas and planned project work.

The soils are generally 24 to 60 inches or deeper. They are well drained and are sodium affected. The vegetation composition of this community is primarily influenced by the soils. Most of these soils are fine sandy loams and silty clay loams. Vegetation can be difficult to establish in the finer clay soils; therefore, site-specific criteria need to be developed for treatment areas and planned project work.

Important procedures for managing this community are removing, controlling, and preventing the spread of noxious and invasive plant species (especially cheatgrass), reducing soil erosion, and improving soil properties, function, and moisture retention.

At the broad-scale level, the SWReGAP land cover grouped vegetation types of intermountain basins greasewood flat and intermountain basins mixed salt desert scrub. These comprise the greasewood community.

The annual production (lbs. /ac.) in the **Table G-1** ESDs only presented shrub production in two ESDs (*Salt Flats R035XA126NM* and *Saline Bottom 6-10" R035XB024NM*). These ESDs can be used to make a very general average of the greasewood community as having approximately 82-86% grass/grass-like, 1-4% forb, and 12-14% shrub components of total HCPC potential average annual production (lbs./ac).

For ground cover, *Saline Bottom 6-10" R035XB024NM* was excluded as it did not list any cover values, but the remaining four ESDs were assessed. The percent bare ground (%) for the ESDs ranged from approximately 35%-65%, with approximately 50% bare ground being the average. Higher percentages of bare ground are typically allowed in the lower elevation/lower precipitation areas. The percent litter cover (%) ranged from 10-25%, with approximately 16-21% as the average across all ESDs. It must be noted that the values utilized vary for individual ESDs.

Indicators

Some of these specific indicators were determined to be more important for the greasewood community and can also be used to assess its health. As with the sagebrush grassland community, ecological succession is a strong indicator in this community as density of black greasewood cover increases with successional stages. Because sites supporting black greasewood typically have saline or sodic soils, black greasewood presence can be indicative of wet to partially west saline conditions, perched water tables, or improper management (NRCS 2007).

As in all vegetation communities, species composition in comparison to the vegetation composition expected in ESDs is important. This community also supports plant species that are tolerant of saline or sodic soils in which other plants are unable to establish. As with other communities, non-native invasive and/or noxious weeds can also potentially enter this community and their presence and prevalence can be an indicator of greasewood community health.

Importance

Soil site stabilization and protection from invasive plant species and/or noxious weeds are important roles in this vegetation community, especially because the greasewood community typically serves as a transition community between riparian areas and upland sagebrush grassland communities. Several raptor species, including golden eagle can be commonly found foraging within this vegetation community. While black greasewood is typically considered poor browse and can be toxic to livestock, the greasewood community affords protective cover for wildlife and livestock, particularly during winter months (NRS 2007a). In addition, this community provides forage for large game and small mammals and browse for livestock in the early spring (NRS 2007b).

Threats

As with other vegetation communities such as the sagebrush grassland and pinyon-juniper communities, factors such as historic grazing, fire suppression, or past vegetation treatments can also lead to a decrease in biodiversity and seral stages. Changes in climate conditions are also a potential threat to this community.

As with the sagebrush grassland community, ecological succession into late seral stages is desirable for some management objectives but can also threaten the community by leading to a reduction in perennial grass understory and key plants such as shadscale from both increased black greasewood and rubber rabbitbrush density and cover. Controlling black greasewood dominance is also difficult as the species utilizes adventitious buds and crown sprouting (NRCS 2007). The greasewood community has undergone vegetation treatments in many areas to restore the grassland component and the watershed and vegetative function of areas, primarily by reducing late ecological successional stage shrub density. As with other vegetation communities, nonnative invasive and noxious weeds can threaten this community, particularly as it departs reference conditions.

Because greasewood communities are often adjacent to riparian communities, soil stability is important; therefore, soil erosion is a threat. A decline in perennial grass cover can also lead to soil degradation and erosion issues and impair water infiltration into the soil.

G.1.7 Riparian

Description

The riparian-vegetation type occupies a minor but important component of surface areas in the FFO. The soils in these areas are typically comprised of stratified sediments of varying textures that are subject to intermittent flooding and/or fluctuating water tables that may reach the surface. The duration of the soil-wetness feature is dependent upon the seasonal meteorological characteristics of the adjacent water body, or the subsurface water table.

Riparian systems are inherently valuable within any landscape and are largely prized for the ecological functions they provide. Components within these systems allow for filtration of sediments, pollutants and nutrients. They provide for the production and cycling of organic matter and also facilitate the spatial and temporal heterogeneity necessary for regeneration of flora and fauna.

The FFO manages 85 separate riparian-wetland reaches containing approximately 112 miles of perennial, intermittent, and ephemeral riparian habitats. The perennial systems flow continuously and include the San Juan, Animas, and La Plata Rivers. The intermittent systems flow for a portion of the year and include portions of Largo Canyon and Cereza Canyon. The ephemeral systems have continuous subsurface water flow and surface flow during precipitation events. The FFO further breaks down riparian vegetation species composition into the active floodplain group and the 100-year floodplain groups.

At the broad-scale level, the SWReGAP land cover mapped vegetation types of Rocky Mountain Lower Montane Riparian Woodlands, North American Arid West Emergent Wash, Invasive Southwest Riparian Woodland and Shrubland, and Rocky Mountain Aspen Forest and Woodland. These vegetation types comprise the FFO riparian/wetland community.

Species in riparian-wetland areas may include willows (coyote willow [Salix exigua], Goodding's willow [S. gooddingii], peachleaf willow [S. amygdaloides], and Bebbs willow [S. bebbiana]), cottonwood (Rio Grande [Populus deltoides ssp. Wislizeni] and narrow leaf cottonwood [P. angstifolius]), stretchberry (the native New Mexico olive [Forestiera pubescens]), and invasives and nonnatives, such as Russian olive (Elaeagnus angustifolia) and tamarisk (saltcedar [Tamarix chinensis]).

Graminoids include spikerush (Eleocharis spp.), sedges (Carex spp.), rushes (Juncus spp. [in wetter low-lying areas in the floodplain]).

Other grasses and forbs include scratchgrass (alkali muhly [Muhlenbergia asperifolia]), alkali sacaton (Sporobolus airoides), spike dropseed (S. contractus), giant dropseed (S. giganteus), sand dropseed (S. cryptandrus), Indian ricegrass (Achnatherum hymenoides), reed canarygrass (Phalaris arundinacea), Rocky Mountain beeplant (Cleome serrulata), lupine (Lupinus spp.), evening primrose (Oenothera spp.), buckwheat (Eriogonum spp.), Indian paintbrush (Castilleja spp.), and hoary tansyaster (Machaeranthera canescens).

Potentially found in disturbed sites are invasive, nonnative downy brome (cheatgrass [Bromus tectorum]), Russian thistle (Salsola tragus), and Russian knapweed (Acroptilon repens) or other knapweed species. In drier portions of the floodplain can be found the native rubber rabbitbrush (Ericameria nauseosa), yellow rabbitbrush (Chrysothamnus viscidiflorus), big sagebrush (Artemisia tridentata), skunkbush (Rhus aromatica), black greasewood (Sarcobatus vermiculatus), and fourwing saltbush (Atriplex canescens).

Soils are a distinct component of this community, and BLM Technical Reference 1737-19 describes the relationship of riparian-wetland soils and hydrology and that *water movement over, into, and through soil is what drives hydrology. Upon reaching a riparian-wetland area landform, moving water is slowed by vegetation (or large woody debris), which provides stability and habitat for aquatic species.*

Active Floodplain

There is an active channel and 100-year floodplain component to riparian systems. Shrubs and trees include willows (coyote, peachleaf, Bebbs, and others), cottonwood (Rio Grande and narrow leaf), stretchberry (the native New Mexico olive), and invasive and nonnative Russian olive and tamarisk (saltcedar). Tree species diversity is low, but age class and structural diversity is high. Younger recruits are found closer to the active channel, while older more mature cottonwoods can be hundreds of yards from the active channel.

The character of the understory depends on previous disturbances, for example, fire, human disturbance, livestock grazing, and flooding. But typically, it includes forbs, grasses, and graminoids, such as horsetail (*Equisetum arvense*), rush, cattails (*Typha latifolia*), spikerush, sedges, James galleta (*Pleuraphis jamesii*), sunflowers (*Helianthus* spp.), Rocky Mountain beeplant, saltgrass (*Distichlis spicata*), scratchgrass (alkali muhly), reed canarygrass, and common reed (*Phragmites australis*). Also, in disturbed sites there may be the invasive nonnatives, Russian thistle, Russian knapweed and other knapweed species, and downy brome (cheatgrass).

PFC assessments are utilized to determine riparian area condition and are further described in its respective section in under *FFO-VCCs*.

Indicators

The PFC assessment refers to a consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of riparian-wetland areas. Because riparian areas are either lotic or lentic, the Lotic and Lentic assessment forms contain a list of physical indicators that can be used to identify the health of a riparian-wetland area. The PFC Lotic Assessment Form is found in BLM Technical Reference 1737-15 Appendix A. The PFC Lentic Assessment Form is found in BLM Technical Reference 1737-16 Appendix A.

Importance

Riparian-wetland areas are critically important in landscapes for biological and ecological, recreational, aesthetic, cultural, and economic reasons (Pritchard 1998). These areas in the FFO provide wildlife habitat, as well as some important recreational uses such as fishing on the San Juan River. Riparian areas affect ground water recharge, water quality, transfer energy, and cycle nutrients among other ecosystem services. These areas are important enough that the FFO has implemented management restrictions such as grazing deferment from May 1st (May 1) to September 30th (9/30) annually, as well as restrictions on activities such as oil and gas development.

Threats

As with most vegetation communities, potential drought and climate change are threats to the riparian community. Drought can negatively impact perennial native vegetation growth and reproduction, particularly for riparian species. Livestock grazing during the plant growing season was a historical threat to riparian communities and annual growing season deferment is now required; however, trespass livestock grazing during this time period remains a threat. Declining condition and management of upland vegetation communities is a threat to riparian areas, particularly through erosion. Furthermore, the erosional features of the arid southwest are a natural occurring threat to riparian areas, in addition to heavy precipitation and flooding events.

G.1.8 Oak Woodlands

Oak woodland comprises a minor part of FFO acreage. Within the FFO, Gambel's oak (*Quercus gambelii*) comprise small dispersed clumps, typically found on mesic (moist) sites with deeper soils, usually as clones of shrubs in dense patches on northeast slopes Gambel's oak stands occur on uplands at elevations 6,500' and greater with the majority found along the New Mexico/Colorado state line and in the extreme northeast section of the field office.

At the broad-scale level, the SWReGAP land cover grouped vegetation types of Rocky Mountain gamble oak-mixed montane shrubland and Rocky Mountain lower montane-foothill shrubland. They comprise the oak woodlands community.

Importance, indicators of health, and threats are not discussed in further detail due to the minimal size of this community.

G.1.9 Ponderosa Pine-Mixed Conifer

Ponderosa pine-mixed conifer forest vegetation community is also very small in the FFO and generally occurs at high elevations ranging from approximately 5,000 to 9,000'. It is dominated by ponderosa pine and commonly includes other species such as oak, juniper, and pinyon. This vegetation community typically occurs with an understory of grasses and forbs although it sometimes includes shrubs. Soil types within this vegetation community tend to be rocky or shallow and range from coarse textured to fine textured.

In areas with a history of fire exclusion or heavy past logging, pole stands occasionally get dense. Grass production is generally moderate but can be quite reduced with erosion or heavy grazing pressure.

Early successional stages generally provide excellent forage on well-maintained sites. Late successional stages may have large trees with heavy duff layers, and forage production is moderate. Dense pole stands may have little or no forage production. Soil types in this vegetation community tend to be rocky or shallow and range from coarse to fine textured.

Importance, indicators of health, and threats are not discussed in further detail due to the minimal size of this community.

G.2 FFO-VCCs

FFO VCCs are based on the combination of many factors that vary within vegetation communities, and include the following:

- ESDs and HCPC, and reference states
- Habitats for threatened, endangered, and special status species managed to provide for recovery and move species toward de-listing.
- Range condition
- Rangeland health assessments
- Wildlife habitat and obligate species that occupy the habitat, including migratory bird nesting habitat
- LANDFIRE condition class
- Vegetation age class
- Non-native invasive and noxious species (weeds) presence
- PFC categories for riparian and wetland areas.

These factors are described individually below to introduce the concepts used in developing the FFO-VCCs.

G.2.1 Ecological Site Descriptions (ESDs) -Historic Climax Plant Community (HCPC) and Reference States

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1068392

The FFO falls within the USDA NRCS defined Land Resource Region (LRR) D-Western Range and Irrigated Pasture and E-Rocky Mountain Range and Forest Region. The LRR contains subunits known as Major Land Resource Areas (MLRAs), which are areas of similar geographic and characteristic land resource units that are important in all planning levels (USDA NRCS 2006). Specifically, the planning area is located within the following MLRAs:

- 35-Colorado Plateau
- 36-Southwestern Plateaus, Mesa, and Foothills
- 48A-Southern Rocky Mountains.

MLRAs contain specific associated units called ecological sites. Ecological sites are classified as either Rangeland or Forestland based on their Reference Plant Community vegetation. Ecological sites are utilized for inventory, assessments, and management (USDA NRCS 2003). The USDA NRCS describes them in the USDA NRCS National Range and Pasture Handbook as specifically the "the product of all the environmental factors responsible for its development, and it has a set of key characteristics that are included in the ecological site description" and that they are "recognized and described on the basis of the characteristics that differentiate it from other sites in its ability to produce and support a characteristic plant community" (USDA NRCS 2003).

Ecological sites are described in reports called Ecological Site Descriptions (ESDs). The information in an ESD is presented in four major areas. According to the NRCS, these areas are site characteristics (features include physiography, climate, soil, and hydrology), plant communities (including plant species, states of vegetation, and ecological dynamics), site interpretations (site-specific management alternatives for the site) and supporting Information (including pertinent literature, sources of data, and information) (USDA NRCS ESDs). ESDs can be found by entering the appropriate MLRA or state on the NRCS Ecological Site Description (ESD) for Rangeland and Forestland Data website. This website can be found at https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD&state=NM&mlra=.

The ESDs contain a description of the HCPC, which is defined in the Interpreting Indicators of Rangeland Health Technical Reference 1734-6 as "the plant community that was best adapted to the unique combination of factors associated with the ecological site. It was in a natural dynamic equilibrium with the historic biotic, abiotic, climatic factors on its ecological site in North America at the time of European immigration and settlement" (Pellant et al. 2005).

As stated earlier, ESDs individually describe the HCPC. Interpreting Indicators of Rangeland Health Technical Reference 1734-6 defines the Potential Natural Plant Community (PNPC) as "a historical term originally defined by A.W. Kuchler as the stable vegetation community which could occupy a site under current climatic conditions without further influence by people. Often used interchangeably with 'potential natural community'" (Pellant et al. 2005). Furthermore, the PNPC can be referred to as the reference state, which is also described in the Interpreting Indicators of Rangeland Health Technical Reference 1734-6 as "the state where the functional capacities represented by soil/site stability, hydrologic function, and biotic integrity are performing at an optimum level under the natural disturbance regime" (Pellant et al. 2005).

However, attaining HCPC for a particular ecological site may not be possible or even desired depending on management objectives. Management objectives may instead allow for a Desired Plant Community (DPC). If this is being used, the reference state will nearly always contain the DPC (Pellant et al. 2005).

ESDs may also contain State-and-Transition Models (STMs), which describe site ecological dynamics. These models provide how transitions between different vegetation states function and the types of management actions that facilitate these. They also describe the characteristics of vegetation states within an ESD.

Range Condition

Ecological sites can be evaluated through range condition classification. Range condition refers to the rangeland health state and typically uses the four categories of "Excellent", "Good", "Fair", and "Poor" (Holechek 2011). These categories were described by Dyksteruis as departure from the HCPC climax vegetation, and were categorized as the following:

- Excellent = 76-100% of climax
- Good = 50-75% of climax
- Fair = 26-50% of climax
- Poor = 0 25% of climax (Holechek 2011).

An ecological site can be evaluated for these categories of range condition through a Range Condition Worksheet. The results of the assessment can provide thresholds for treatment based on the rating for the ecological site and management objectives. Range condition worksheets generate range condition ratings by considering the factors of plant composition (%) based on annual production (lbs.) by weight found at a site or by percent cover, the proportion of "allowable" species from a site according to the reference ESD, and the amount of annual production (lbs.) from a site as compared to the HCPC values in the reference ESD. Undesirable species or a disproportionate amount of desirable or allowable species can affect this rating by replacing desirable or allowable species. The range condition worksheet also allows range condition trend to be assessed as "Improving", "Stationary", or "Declining" by rating composition change, abundance of seedlings and young plants, plant residues, plant vigor, and soil surface condition.

Again, attaining or using HCPC values may not be relevant to the management objectives for a particular site. Range condition classes may also not be relevant to the management objectives. For example, "Excellent" in relation to HCPC does not necessarily always directly equate to "excellent" in terms of management objectives. Additionally, a "Fair" range condition rating in terms of climax vegetation may equate to acceptable or "good" conditions for certain management objectives. For example, management objectives may prescribe an area to be targeted for treatment to optimize a certain wildlife species habitat, which may be different from an area targeted for livestock grazing or watershed function.

Range condition classes of "Excellent" through "Poor" can also be replaced with the following terms (Holechek 2011):

- Excellent = Climax
- Good = High Seral or late seral
- Fair = Mid Seral
- Poor = Low Seral or early seral

Trend and whether it is upward, downward, or static can also be assessed over time and utilized in relation to range condition and/or seral stage.

Rangeland Health Assessments and New Mexico Standards for Public Land Health

Rangeland Health Assessments (RHAs) are regularly utilized by rangeland managers to evaluate the ecological processes (water cycle, energy flow, and nutrient cycle) of an ecological site through the three attributes of rangeland health - soil/site stability, hydrologic function, and biotic integrity. Interpreting Indicators of Rangeland Health Technical Reference 1734-6 defines rangeland health as "the degree to which the integrity of the soil, vegetation, water, and air, as well as the ecological processes of the rangeland ecosystem, are balanced and sustained. Integrity is defined as maintenance of the structure and functional attributes characteristic of a locale, including normal variability" (Pellant et al. 2005).

These attributes are evaluated through 17 qualitative and quantitative indicators. Results of an RHA will allow the determination of whether or not an ecological site is meeting rangeland health and inform management decisions. RHA forms as well as a more in-depth description the process and indicators are found in the Interpreting Indicators of Rangeland Health Technical Reference 1734-6.

In the FFO, Rangeland Health Assessments are typically utilized for assessing sites in reference to Rangeland ESDs as Forestland ESDs are not typically key grazing areas.

RHAs are also used in the FFO to determine if the New Mexico Standards for Public Land Health (BLM 2001) Upland Sites Standard, Biotic Communities, Including Native, Threatened, Endangered, and Special Status Species Standard, and the Riparian Sites Standards are being met.

G.2.2 Wildlife and Wildlife Habitat, including Special Status & Threatened & Endangered Species

Habitat for both wildlife and special status species and threatened and endangered (T&E) plant and animal species is important. For wildlife, plant species composition, vegetative age classes, fragmentation and continuity, and patch size and "mosaics" are important for habitat. The presence or absence of obligate species as well as abundance can indicate the overall health for a vegetation community. For special status and T&E plant species habitat, a healthy overall vegetation community reflected in other rating factors such as RHAs and minimizing non-native invasive and noxious species is important.

G.2.3 LANDFIRE Vegetation Condition Classes (VCCs)

LANDFIRE VCCs are categories of Vegetation Departure (VDEP) layers and describe current vegetation the overall departure level and indicate present vegetation's general departure level from simulated historical reference conditions (LANDFIRE). VDEP ranges on a scale from 0 – 100 (LANDFIRE).

According to LANDFIRE, there are six VCC classes which can be condensed into the following three classes. VCC 1 represents ecosystems with low departure and a VDEP of 0 to 33. VCCC 2 represents ecosystems with moderate departure and a VDEP of 34 to 66. VCC 3 represents ecosystems with high departure and a VDEP of 67 to 100.

G.2.4 Age Class

Diversity of age classes for vegetation is important for a vegetation community in terms of ecological processes, resiliency, and wildlife habitat, particularly in helping form "mosaics" on the landscape. Different age classes of vegetation also allow for recruitment and replacement plants.

G.2.5 Proper Functioning Condition (PFC)

BLM Technical Reference 1737-15 refers to PFC as a qualitative method for assessing the condition of riparian-wetland areas. The term PFC is used to describe both the assessment process, and a defined, on the-ground condition of a riparian-wetland area.

The PFC assessment considers three primary factors when qualitatively examining the condition of a riparian-wetland system which are the hydrology, vegetation, and the geomorphological properties of the area (Prichard 1998). PFC assessments are specific for riparian areas but can also help indicate the health of upland communities.

BLM Technical Reference 1737-15 states that a riparian-wetland area is considered to be in proper functioning condition when adequate vegetation, landform, or large woody debris is present to:

- *dissipate stream energy associated with high waterflow, thereby reducing erosion and improving water quality;*
- *filter sediment, capture bedload, and aid floodplain development;*
- *improve flood-water retention and ground-water recharge;*
- *develop root masses that stabilize streambanks against cutting action;*
- *develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses;*
- *support greater biodiversity.*

PFC assessment forms assess whether or not the uplands are contributing to the "PFC", "Fair with Upward, Downward, or Not Apparent Trend", or "Not Functioning" ratings.

G.2.6 Non-Native Invasive & Noxious Species (Weeds) Presence

Noxious and invasive non-native species or weeds are aggressive, typically non-native, ecologically damaging, and undesirable plants. They severely threaten biodiversity, habitat quality, and ecosystems. Because of their aggressive nature, noxious weeds can spread into established plant communities mainly through ground disturbing activities that disturb vegetation and soil, such as clearing ground for development or recreation and/or animal activity and overgrazing. They will also invade areas as the native plant community declines and replace desirable species. The presence and amount or proportion of weeds can be reflected in RHAs and other assessment methods. Noxious weeds are managed according to their classifications on the New Mexico Department of Agriculture Noxious Weed List.

G.3 Farmington Field Office Vegetation Condition Classes (FFO-VCCs)

Utilizing the described factors, four FFO-VCCs were defined for use to describe the current condition of the communities and in alternatives development to set management objectives for each alternative. The highest condition of a specific vegetation community would represent Class 1 and Classes 2-4 represent departures from FFO-VCC 1 conditions. As each vegetation community varies in the composition of plant communities, the indicators are not all weighted equally. Any action to be taken in accordance with management objectives would be determined at the site-specific level.

G.3.1 FFO-VCC 1

FFO-VCC 1 is defined as managing for 76-100% of the relevant ESD(s) potential HCPC vegetation or described reference state(s). Trends would be "Stationary/Static" or "Upward/Improving". Additionally, the following indicators may be taken into consideration and contribute to the vegetation community's overall condition:

1. Rangeland Health Assessments in vegetation communities assessed would be targeted to rate as "None to Slight" in all categories and meet the fundamentals of rangeland health.
2. New Mexico Standards for Public Land Health would be met.
3. Management for this class would include managing for the percent (%) bare ground, litter, and foliar cover described in the ESD. Less than 10% weeds by percent cover would be allowed.
4. LANDFIRE VCC 1 would be targeted to occur in the community.
5. Habitats for threatened, endangered, and special status species managed to provide for recovery and move species toward de-listing.
6. An abundance and diversity of wildlife and obligate species to the specific community would occur for what is expected.
7. There would be a distribution of vegetation age classes.
8. Wildlife and migratory bird nesting habitat would include being intact with limited fragmentation and would include patches and mosaics.
9. For riparian areas, ratings would be PFC with an upward trend.

G.3.2 FFO-VCC 2

FFO-VCC 2 is defined as managing for 51-76% of the relevant ESD(s) potential HCPC vegetation or described reference state(s). Trends would be "Stationary/Static" or "Upward/Improving". Within the "sideboards" of attaining an overall condition rating of 51-75% of the relevant ESD potential HCPC vegetation or described reference state, the above mentioned indicators 1-9 in FFO-VCC 1 could slightly depart from the baselines described, but their status is evaluated and any action to be taken in accordance with management objectives is determined at the site-specific level.

G.3.3 FFO-VCC 3

FFO-VCC 3 is defined as managing for 26-50% of the relevant ESD(s) potential HCPC vegetation or described reference state(s). Trends would be "Stationary/Static" or "Upward/Improving". Within the "sideboards" of attaining an overall condition rating of 26-50% of the relevant ESD potential HCPC vegetation or described reference state, the abovementioned indicators 1-9 in FFO-VCC1 1 could depart from these baselines described, but their status is evaluated and any action to be taken in accordance with management objectives is determined at the site-specific level.

G.3.4 FFO-VCC 4

FFO-VCC 4 is defined as managing for 0-25% of the ESD(s) HCPC potential climax vegetation or described reference state(s). Trends would be "Stationary/Static". Within the "sideboards" of attaining an overall condition rating of 0-26% of the relevant ESD potential HCPC vegetation or described reference state, the abovementioned indicators 1-9 in FFO-VCC 1 could depart from these baselines described, but their status is evaluated and any action to be taken in accordance with management objectives is determined at the site-specific level.

G.4 References

Anderson, J. E and M. L. Shumar. 1986. Impacts of black-tailed jackrabbits at peak population densities on sagebrush vegetation. Journal of Range Management. 39(2): 152-155.

Blaisdell, J. P. and R. C. Holmgren. 1984. Managing Intermountain rangelands--salt-desert shrub ranges. Gen. Tech. Rep. INT-163. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 52 p.

Holechek, J. L., R. D. Peiper, and H. C. Herbel. 2011. Range Management Principles and Practices. 6th ed. Prentice Hall. Boston. Pages 129-134.

LANDFIRE. https://www.landfire.gov/index.php

Lewis, L. 2003. *Riparian-Wetland Soils*. BLM Technical Reference (1737-19).

Medin, D.E. 1986. Grazing and passerine breeding birds in a great basin low-shrub desert. Great Basin Naturalist: Vol. 46: No. 3, Article 27.

NRCS. 2007a. Ecological site description: Loamy Bottom 6-10" p.z. Perennial R035XB269AZ. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB269AZ . Accessed 7.20.2015. (2007a)

NRCS. 2007b. Technical Note: Managing Black Greasewood Sites. TN Plant Materials No. 15.

NRCS. 2008. Ecological site description: Clayey R035XA128NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XA128NM. Accessed 7.14.2015. (2008a)

NRCS. 2008. Ecological site description: Clayey R035XB004NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB004NM. Accessed 7.14.2015. (2008b)

NRCS. 2008. Ecological site description: Clayey R036XB002NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R036XB002NM. Accessed 7.14.2015. (2008c)

NRCS. 2008. Ecological site description: Clay Loam Terrace (sodic) 7-10" R035XB016NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB016NM. Accessed 7.14.2015. (2008d)

NRCS. 2008. Ecological site description: Deep Sand R035XB007NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB007NM. Accessed 3.5.2015. (2008e)

NRCS. 2008. Ecological site description: Gravelly Fan R036XB003NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R036XB003NM. Accessed 3.9.2015. (2008f)

NRCS. 2008. Ecological site description: Limy R035XB003NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB003NM. Accessed 3.9.2015. (2008g)

NRCS. 2008. Ecological site description: Loamy R035XB001NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?id=R035XB001NM&rptLevel=all&approved=yes&repType=regular&scrns=&comm=. Accessed 7.20.2015. (2008h)

NRCS. 2008. Ecological site description: Loamy Savanna R036XB016NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R036XB016NM. Accessed 3.6.2015. (2008i)

NRCS. 2008. Ecological site description: Loamy 6-10" terrace R035XB020NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB020NM. Accessed 7.14.2015. (2008j)

NRCS. 2008. Ecological site description: Loamy Upland 7-10" R035XB021NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB021NM. Accessed 7.14.2015. (2008k)

NRCS. 2008. Ecological site description: Saline Bottom 6-10" R035XB024NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB024NM. Accessed 7.14.2015. (2008l)

NRCS. 2008. Ecological site description: Salt Flats R035XB005NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB005NM. Accessed 7.14.2015. (2008m)

NRCS. 2008. Ecological site description: Sandy R035XB002NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB002NM. Accessed 3.5.2015. (2008n)

NRCS. 2008. Ecological site description: Sandy Loam Upland 6-10" R035XB030NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?approved=yes&repType=regular&id=R035XB030NM. Accessed 7.14.2015. (2008o)

NRCS. 2008. Ecological site description: Sandy Terrace 6-10" sodic R035XB034NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB034NM. Accessed 7.14.2015. (2008p)

NRCS. 2008. Ecological site description: Sandy Upland 6-10" R035XB035NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB035NM. Accessed 7.14.2015. (2008q)

NRCS. 2008. Ecological site description: Sandy Upland 6-10" sodic R035XB033NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?id=R035XB033NM&rptLevel=all&approved=yes&repType=regular&scrns=&comm=. Accessed 7.20.2015. (2008r)

NRCS. 2008. Ecological site description: Shallow R035XB006NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?approved=yes&repType=regular&id=R035XB006NM. Accessed 3.5.2015. (2008s)

NRCS. 2008. Ecological site description: Sodic Slopes R035XB008NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB008NM. Accessed 7.14.2015. (2008t)

NRCS. 2008. Ecological site description: Stony Loam R036XB018NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R036XB018NM. Accessed 3.9.2015. (2008u)

NRCS. 2009. Ecological site description: Loamy R036XB006NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R036XB006NM. Accessed 3.5.2015. (2009)

NRCS. 2010. Ecological site description: Loamy Upland Sodic R035XB022NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB022NM. Accessed 7.14.2015. (2010a)

NRCS. 2010. Ecological site description: Salt Flats R035XA126NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XA126NM. Accessed 7.14.2015. (2010b)

NRCS. 2010. Ecological site description: Salty Bottomland R036XB010NM. United States Department of Agriculture, Natural Resources Conservation Service. Accessed 7.14.2015. (2010c)

NRCS. 2010. Ecological site description: Sandy R035XB011NM. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?id=R036XB011NM&rptLevel=all&approved=yes&repType=regular&scrns=&comm=. Accessed 7.14.2015. (2010d)

NRCS. 2012. Ecological site description: Mudstone/Sandstone Hills 6-10" p.z. R035XB201AZ. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB201AZ. Accessed 7.14.2015. (2012a)

NRCS. 2012. Ecological site description: Sandstone Upland 13-17" p.z. (JUOS, PIED) F035XF627AZ. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=F035XF627AZ. Accessed 7.14.2015. (2012b)

NRCS. 2012. Ecological site description: Sandy Bottom 6-10" p.z. R035XB273AZ. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB273AZ. Accessed 7.20.2015. (2012c)

NRCS. 2012. Ecological site description: Sandy Loam Upland 13-17" p.z. (JUOS, PIED) F035XF628AZ. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=F035XF628AZ. Accessed 7.14.2015. (2012d)

NRCS. 2012. Ecological site description: Shale Hills 6-10" p.z. R035XB268AZ. United States Department of Agriculture, Natural Resources Conservation Service. https://esis.sc.egov.usda.gov/Welcome/pgSelectReportType.aspx?approved=yes&id=R035XB268AZ. Accessed 7.14.2015. (2012e)

Pellant, M., P. Shaver, D. A. Pyke, and J. E. Herrick. 2005. Interpreting indicators of rangeland health, version 4. Technical Reference 1734-6. U.S. Department of the Interior, Bureau of Land Management, National Science and Technology Center, Denver, CO. BLM/WO/ST-00/001+1734/REV05. 122 pp. http://www.blm.gov/nstc/library/pdf/1734-6rev05.pdf. Accessed 3.9.2015

Prichard, D. 1998. *A User Guide to Assess Proper Functioning Condition and the Supporting Science for Lotic Areas.* BLM Technical Reference (1737-15).

Prichard, D. 2003(Rev.). *A User Guide to Assess Proper Functioning Condition and the Supporting Science for Lentic Areas.* BLM Technical Reference (1737-16).

United States Department of Agriculture, Natural Resources Conservation Service. Ecological Sites (USDA NRCS ESs). http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1068392. Accessed 3.9.2015 (NRCS ES Web)

United States Department of Agriculture, Natural Resources Conservation Service. Ecological Site Descriptions (USDA NRCS ESDs). http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/ecoscience/desc/. Accessed 3.9.2015 (NRCS_ESDs_Web)

United States Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). 2003. National Range and Pasture Handbook. Grazing Lands Technology Institute. http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17734.wba. Accessed 3.9.2015 (NRCS 2003)

______. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_050898.pdf. Accessed 3.9.2015 (NRCS 2006)

______. 2008. Ecological Sites: Understanding the Landscape Fact Sheet. http://nitcnrcsbase-www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1043492.pdf. Accessed 3.9.2015 (NRCS 2008 Fact Sheet)

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Appendix H

Rationale for CCNHP Restriction Zones

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations	Full Phrase
BLM	United States, Department of the Interior, Bureau of Land Management
CCNHP	Chaco Culture Natural Historic Park
dBA	A-weighted decibel
FERC	Federal Energy Regulatory Commission
IOS	International Organization for Standardization
NHPA	National Historic Preservation Act
NPS	National Park Service
NRHP	National Register of Historic Places
NSO	no surface occupancy
TCP	traditional cultural property
UNESCO	United Nations Educational, Scientific and Cultural Organization
VRM	Visual Resource Management

Appendix H. Rationale for CCNHP Restriction Zones

This appendix describes the rationale behind the various sizes of restriction zones around CCNHP considered under BLM Alternatives A, B, and C, including sub-alternatives.

The CCNHP hosts the densest and most exceptional concentration of pueblos in the American Southwest. The park is located in northwestern New Mexico, between Albuquerque and Farmington, in a remote canyon cut by the Chaco Wash. Containing the most sweeping collection of ancient ruins north of Mexico, the CCNHP preserves one of the most important pre-Columbian cultural and historical areas in the United States.

The CCNHP and its cultural resources are near the south edge of the planning area and are listed as Chaco Protection Sites under Public Law 96-550 and as United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage inscribed properties. Many of the sites in the CCNHP are considered eligible to the NRHP under multiple criteria, including A, C, and D. Part of the integrity of these historic properties is related to association, setting, and feeling; therefore, potential adverse effects can be related to the visual and auditory environment. Chacoan cultural sites can be also fragile. For example, concerns with erosion caused by tourists led to the closure of Fajada Butte to the public. The CCNHP and its sites are also considered sacred ancestral homelands by the Navajo and Pueblo people, who maintain oral accounts of their historical migration from Chaco and their spiritual relationship to the land.

The provided rationale for the restriction zones around the CCNHP incorporates the information above about how the historic properties in the park are eligible to the NRHP and how they may be impacted, along with other guidance from the BLM on visual and auditory resource management. This includes the BLM Manual 8400 on Visual Resource Management, guidance from other areas such as the BLM standards and guidance relating to VRM and the assessment of effects under the NHPA (best summarized in Appendix C to the Wyoming Protocol between BLM and the SHPO]), and local efforts to minimize and mitigate visual and auditory effects on similar Chacoan resources on BLM-managed lands outside the CCNHP, such as Pierre's Site—a Chacoan outlier site (Haymes 2018). The BLM's VRM Manual 8400 defines the foreground-middleground distance zones as "the area visible from a travel route, use area, or other observation point to a distance of 3 to 5 miles" and the background distance zone as "the visible area of a landscape…usually from a minimum of 3 to 5 miles to a maximum of about 15 miles from a travel route, use area, or other observer point" (BLM 1984).

The natural soundscapes encountered at CCNHP are exceptional. The NPS has completed an Acoustic Monitoring Report through the National Resource Stewardship and Science office documenting the soundscape present at CCNHP. The report is available here: https://www.nps.gov/subjects/sound/acousticmonitoring_reports.htm. The NPS estimates from this report that ambient sound levels across the CCNHP vary from 24.4 to 35.3 dBA, an expression of the relative loudness of sounds in air as perceived by the human ear. Based on information from the International Organization for Standardization (IOS) and the Federal Energy Regulatory Commission (FERC), as well as local mean atmospheric conditions, the NPS estimates that noise from oil and gas construction and drilling activities would attenuate to 35.3 dBA (the maximum ambient sound level across the CCNHP) at 0.7 miles away from the well location.

Similarly, this noise is estimated to attenuate to 24 dBA (the minimum ambient sound level) at 1.75 miles away from the well location.

Additionally, Haymes (2018) suggests that under normal circumstances, oil and gas development does not result in permanent impacts on the visual or auditory environment for historic properties. The rationale for this is that all fluid mineral extraction facilities will ultimately cease production, after which wells are plugged and abandoned, aboveground facilities removed, and pads reclaimed. Leases may be held by production for decades, with some near Kutz Canyon foreseeably entering a century of production in the next 20 years. More typically, facilities remain in active production for about 30 to 40 years. Necessarily, the sounds related to the oil and gas operations cease once the facility is closed; however, pads need to be reclaimed to remove most adverse visual effects on historic properties. Haymes (2018) notes that while "the success of reclamation depends greatly on a location's geography and surrounding vegetation, pads are generally reclaimed sufficiently well to fully reverse any substantial impact on a site's viewshed."

During scoping, there were diverse comments received from Tribal communities and individuals on the potential impacts from oil and gas development and hydraulic fracturing. Some Tribal members, including individuals from Pueblos and the Navajo Nation, felt that oil and gas infrastructure growth was impacting cultural and natural resources, along with Tribal lifeways or CIMPPs. They indicated that agencies lack the ability to identify traditional resources or other sacred sites to which Tribes have long-standing affiliations, and as a result the ongoing fluid mineral development was destroying part of these Tribes' cultural landscape. Tribal members also expressed their concerns about the broad effects from oil and gas development that result in an altered landscape where individuals are no longer able to complete early morning prayers, night observances, or other ceremonies due to the impaired visual and auditory setting. The restriction zones described below are designed to reduce impacts on these types of cultural resources important to Tribes in the CCNHP and surrounding area.

The various closure and NSO zones around the CCNHP under BLM Alternatives A, B, and C, including sub-alternatives, are illustrated in **Figure H-1**, BLM Alternatives and Fluid Mineral Leasing Allocations Related to the CCNHP. Discussion of the specific rationales behind the zones under each alternative is included in the sections below.

H.1 BLM Alternative A – No Leasing Closure (Miles 0 to 2 around CCNHP) and NSO Stipulation (Miles 2 to 4 around CCNHP)

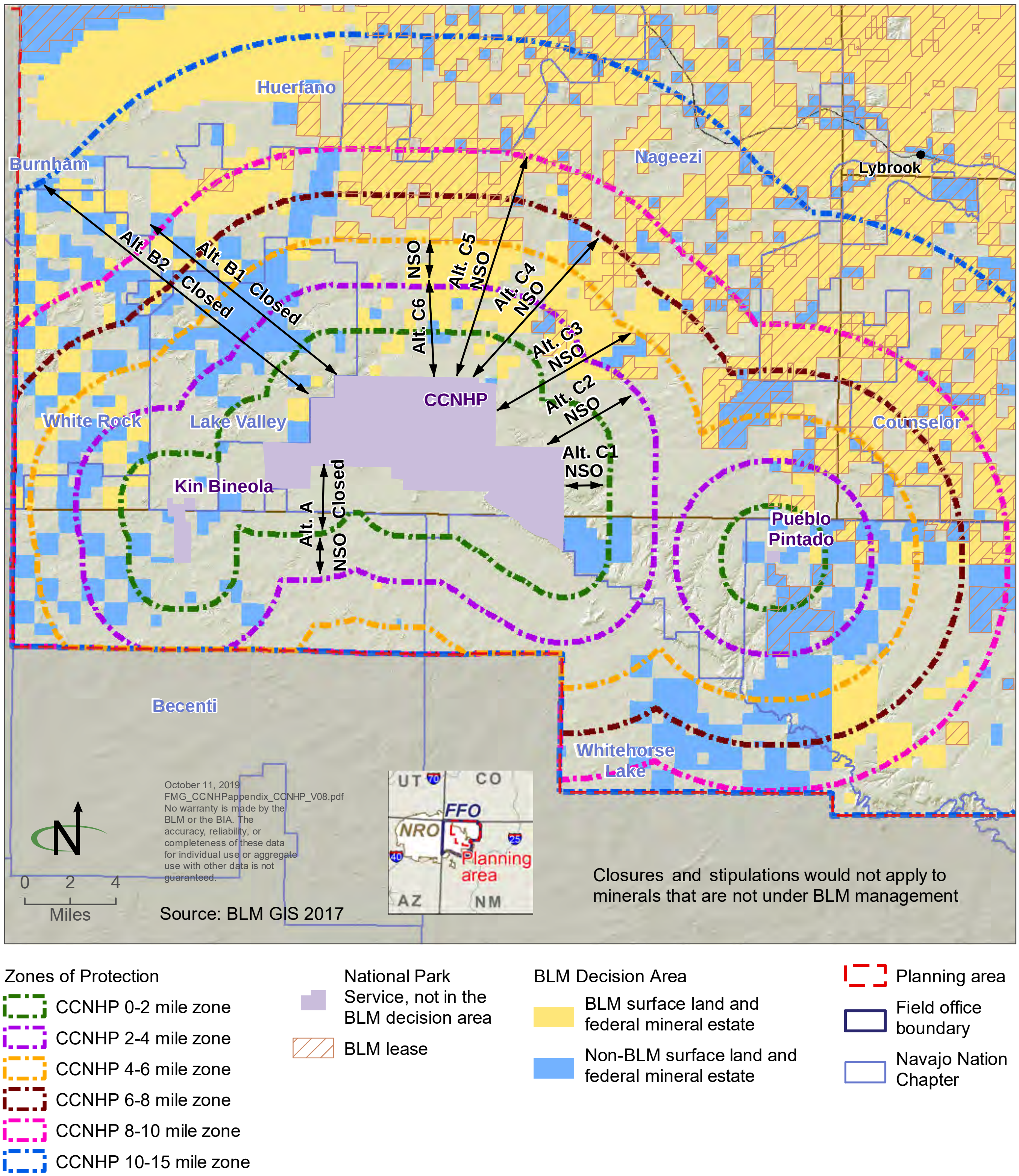
The no leasing zone from miles 0 to 2 around CCNHP under this alternative is designed to align with the highest-priority foreground, and the NSO zone from miles 2 to 4 is designed to align with the foreground-middleground distance as well as some of the background distance around CCNHP (see **Figure H-1**). Prohibiting development in this area is meant to reduce visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to CCNHP and Chacoan roads and outliers. Additionally, Haymes (2018) states that "observations suggest stationary facilities other than tanks or other large buildings are negligibly visible at distances greater than 2700 meters, or 1 2/3 miles."

The NPS estimates that in the area around CCNHP, lighting from drilling rigs without shielding is visible from 8 miles away and equivalent in brightness to Venus, while mitigation for lighting can reduce this distance to 5 miles. Flaring of methane from wells has an especially noticeable impact on the viewshed at night, both in terms of individual bright spots on the landscape and contribution to overall night sky glow. Prohibiting new leasing and surface development in the no leasing and NSO zones out to 4 miles around the CCNHP under this alternative, in combination with possible lighting mitigation measures, is also meant to reduce nighttime visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to the park.

Figure H-1

BLM Alternatives and Fluid Mineral Leasing Allocations Related to the CCNHP

Labels accompanying arrows on map describe allocations by alternative from Chapter 2, **Table 2-3**, Description of BLM No Action Alternative and Alternatives A, B, C, and D.



The 2-mile leasing closure and 2-mile NSO zone under this alternative are designed to align with and exceed the distance needed for the noise from oil and gas activities to attenuate and not exceed background noise levels. The restriction zones under this alternative are also designed to reduce potential impacts on the cultural resources important to Tribes in the CCNHP as certain aspects of the visual and auditory environment can be significant for ceremonies or other activities conducted at these locations.

H.2 BLM Sub-alternative B1 – No Leasing Closure (Miles 0 to 10 around CCNHP)

The no leasing zone from miles 0 to 10 around CCNHP under this sub-alternative (see **Figure H-1**) is designed to align with the foreground-middleground distance zones as well as the majority of the background distance zone around the CCNHP.

Prohibiting new leasing and surface development in the no leasing zone up to 10 miles around CCNHP under this sub-alternative is meant to reduce nighttime visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to the park. Because of the closure considered under this alternative, nighttime visual impacts would be minimized regardless of whether additional lighting mitigation measures are implemented.

The no leasing zone out to 10 miles around the CCNHP under this sub-alternative both encompasses and goes beyond the distance needed for noise from oil and gas activities to attenuate and not exceed background noise levels in the CCNHP. The restriction zone under this sub-alternative is also designed to reduce potential impacts on the cultural resources important to Tribes in the CCNHP as certain aspects of the visual and auditory environment can be significant for ceremonies or other activities conducted at these locations.

H.3 BLM Sub-alternative B2 – No Leasing Closure (Miles 0 to 15 around CCNHP)

The no leasing zone from miles 0 to 15 around CCNHP under this sub-alternative (see **Figure H-1**) is designed to align with the foreground-middleground distance zones as well as the maximum background distance zone around the CCNHP.

Prohibiting new leasing and surface development in the no leasing zone up to 15 miles around CCNHP under this sub-alternative is meant to reduce nighttime visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to the park. Because of the closure considered under this alternative, nighttime visual impacts would be minimized regardless of whether additional lighting mitigation measures are implemented.

The no leasing zone out to 15 miles around the CCNHP under this sub-alternative both encompasses and goes beyond the distance needed for noise from oil and gas activities to attenuate and not exceed background noise levels in the CCNHP. The restriction zone under this sub-alternative is also designed to reduce potential impacts on the cultural resources important to Tribes in the CCNHP as certain aspects of the visual and auditory environment can be significant for ceremonies or other activities conducted at these locations.

H.4 BLM Sub-alternative C1 – NSO Stipulation (Miles 0 to 2 around CCNHP)

The NSO zone from miles 0 to 2 around CCNHP (see **Figure H-1**) is designed to align with the highest-priority foreground viewshed around the CCNHP. Additionally, Haymes (2018) states that "observations suggest stationary facilities other than tanks or other large buildings are negligibly visible at distances greater than 2700 meters, or 1 2/3 miles." Prohibiting new surface development in this area is meant to reduce visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to CCNHP and on community residents.

Applying an NSO stipulation from miles 0 to 2 around CCNHP under this sub-alternative is meant to reduce nighttime visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to the park. Application of lighting mitigation measures could further reduce these impacts.

The NSO zone out to 2 miles around CCNHP under this sub-alternative is designed to align with the distance needed for the noise from oil and gas activities to attenuate and not exceed background noise levels. The restriction zone under this sub-alternative is also designed to reduce potential impacts on the cultural resources important to Tribes in the CCNHP as certain aspects of the visual and auditory environment can be significant for ceremonies or other activities conducted at these locations.

H.5 BLM Sub-alternative C2 – NSO Stipulation (Miles 0 to 4 around CCNHP)

The NSO zone from miles 0 to 4 around CCNHP (see **Figure H-1**) is designed to align with the foreground-middleground distance as well as some of the background distance around CCNHP (see **Figure H-1**). Prohibiting new surface development in this area is meant to reduce visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to CCNHP and Chacoan roads and outliers. Additionally, Haymes (2018) states that "observations suggest stationary facilities other than tanks or other large buildings are negligibly visible at distances greater than 2700 meters, or 1 2/3 miles."

Prohibiting new surface development in the NSO zone out to 4 miles around the CCNHP under this sub-alternative, in combination with possible lighting mitigation measures, is also meant to reduce nighttime visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to the park.

The 4-mile NSO zone under this sub-alternative is designed to align with and exceed the distance needed for the noise from oil and gas activities to attenuate and not exceed background noise levels. The restriction zone under this sub-alternative is also designed to reduce potential impacts on the cultural resources important to Tribes in the CCNHP as certain aspects of the visual and auditory environment can be significant for ceremonies or other activities conducted at these locations.

H.6 BLM Sub-alternative C3 – NSO Stipulation (Miles 0 to 6 around CCNHP)

Similar to BLM Sub-alternative C2, the NSO zone from miles 0 to 4 around CCNHP (see **Figure H-1**) is designed to align with the foreground-middleground distance as well as some of the background distance around CCNHP (see **Figure H-1**). Prohibiting new surface development in the NSO zone out to 6 miles around the CCNHP under this sub-alternative, in combination with possible lighting mitigation measures, is also meant to reduce nighttime visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to the park. Additionally, this NSO zone would mitigate noise impacts as described under BLM Sub-alternative C2.

H.7 BLM Sub-alternative C4 – NSO Stipulation (Miles 0 to 8 around CCNHP)

Similar to BLM Sub-alternative C2, the NSO zone from miles 0 to 8 around CCNHP (see **Figure H-1**) is designed to align with the foreground-middleground distance as well as more of the background distance around CCNHP (see **Figure H-1**). Prohibiting new surface development in the NSO zone up to 8 miles around CCNHP under this sub-alternative is meant to reduce nighttime visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to the park. Because of the NSO zone considered under this alternative, nighttime visual impacts would be minimized regardless of whether additional lighting mitigation measures are implemented. Additionally, this NSO zone would mitigate noise impacts as described under BLM Sub-alternative C2.

H.8 BLM Sub-alternative C5 – NSO Stipulation (Miles 0 to 10 around CCNHP)

Similar to BLM Sub-alternative C2, the NSO zone from miles 0 to 10 around CCNHP (see **Figure H-1**) is designed to align with the foreground-middleground distance as well as the majority of the background distance around CCNHP (see **Figure H-1**). Like under BLM Sub-alternative C4, because of the NSO zone considered under this alternative, nighttime visual impacts would be minimized regardless of whether additional lighting mitigation measures are implemented. Additionally, this NSO zone would mitigate noise impacts as described under BLM Sub-alternative C2.

H.9 BLM Sub-alternative C6 – No Leasing Closure (Miles 0 to 4 around CCNHP); NSO Stipulation (Miles 4-6 around CCNHP)

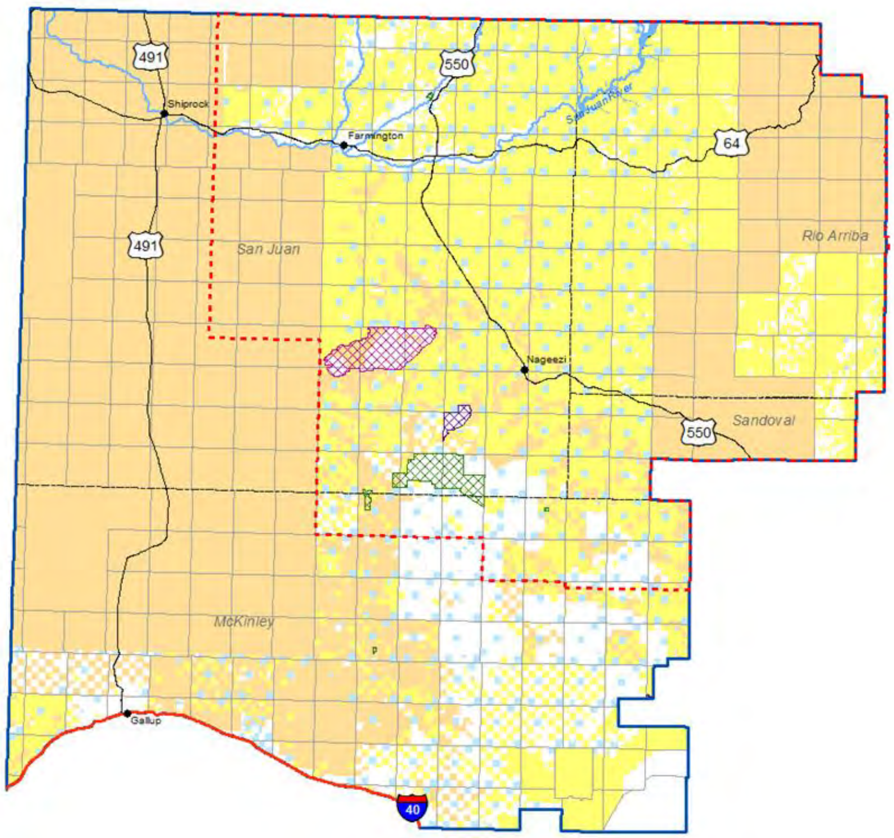
Similar to BLM Sub-alternative C3, the no leasing zone from miles 0 to 4 around CCNHP and the NSO zone from miles 4 to 6 around CCNHP (see **Figure H-1**) are designed to align with the foreground-middleground distance as well as some of the background distance around CCNHP (see **Figure H-1**). Prohibiting new surface development in the no leasing and NSO zones out to 6 miles around the CCNHP under this sub-alternative, in combination with possible lighting mitigation measures, is also meant to reduce nighttime visual impacts from oil and gas facilities on the cultural setting and recreational experience for visitors to the park. Additionally, these no leasing and NSO zones would mitigate noise impacts as described under BLM Sub-alternative C2.

Appendix I

Reasonable Foreseeable Development (RFD) Scenario for Oil and Gas Activities, Mancos-Gallup RMPA Planning Area; Updates to the RFD; and the 2019 Water Support Document

Reasonable Foreseeable Development Scenario for Oil and Gas Activities

Mancos-Gallup RMPA Planning Area, Farmington Field Office, northwestern New Mexico



Farmington Field Office, northwestern New Mexico. Mancos-Gallup RMPA Planning Area marked by red dashed outline.

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and
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United States Department of the Interior
Bureau of Land Management

Final Report

February 2018

New Mexico State Office

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

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Introduction

The purpose of this reasonable foreseeable development (RFD) scenario is to analyze the known and potential oil and gas resources within a portion of the Farmington Field Office in northwestern New Mexico, and to project the potential future oil and gas development activity for the next 20 years (2018-2037) based on logical and technical assumptions. Historic and current activity, occurrence potential, projected development potential (including projections for vertical and horizontal wells drilled during the life of the plan), estimated future surface disturbance, estimated water use for hydraulic fracturing, and estimated oil and gas production volumes are presented. This RFD scenario has been prepared in support of the Farmington Field Office's Mancos-Gallup Resource Management Plan Amendment (RMPA). Previous RFD scenarios for portions of the field office were completed in 2001, 2014, and 2015.

The RMPA Planning Area is encompassed by the Farmington Field Office administrative boundary, and contains approximately 4.2 million total acres of all mineral ownership types in portions of San Juan, Rio Arriba, Sandoval, and McKinley Counties. Federal oil and gas minerals in the area cover 2.1 million acres (51%). Of the Federal minerals, 1.8 million acres (85%) are leased and 300,000 acres (15%) are currently unleased. Indian-owned oil and gas minerals (allotted and tribal) cover 1.4 million acres (34% of the Planning Area). Portions of oil and gas minerals are State-owned or owned privately and are not subject to the RMPA. Specially-designated areas that are unavailable for leasing are shown in hatched shading on **Figure 1.**

Under the RMPA, the Federal oil and gas minerals managed by the BLM that could potentially be available for leasing total 2 million acres—approximately 47% of the planning area and 92% of Federal fluid minerals within the planning area. All BLM-managed oil and gas minerals within the RMPA Planning Area boundary are covered by decisions made in the BLM Farmington Field Office Mancos-Gallup RMPA. All acreages presented herein are based on geographic information systems (GIS) calculations and should be considered approximate.

Guidance and Data Sources

The BLM derives guidance for RFD scenarios from the "Interagency Reference Guide: Reasonable Foreseeable Development Scenarios and Cumulative Effects Analysis, 2004" developed by the Rocky Mountain Leadership Forum, a consortium of Federal natural resource management agencies. This document defines the RFD scenario as a reasonable projection of the most likely anticipated oil and gas activity supported by a clearly stated set of assumptions. This projection establishes a baseline scenario that is unconstrained by management imposed conditions and is based on historical and geological parameters. This baseline RFD scenario can then be used to compare the resource management plan with its alternatives and to analyze the long-term effects that could result from oil and gas activities. It must be emphasized that the RFD scenario is not a decision document and does not establish limitations on development.

Information presented in this report was compiled from various sources. Historical and current well data (including production volumes) were provided by IHS Energy. Land and mineral ownership data as well as most other GIS data were provided by the BLM New Mexico State Office and the Farmington Field Office. Geological data were sourced from New Mexico Bureau of Geology and Mineral Resources reports, U.S. Geological Survey Oil and Gas Assessments, and various professional publications. Hydraulic fracturing fluid volumes were sourced from reports published by the New Mexico Bureau of Geology and Mineral Resources and by the U.S. Environmental Protection Agency. Information regarding price trends was taken from the Energy Information Administration. All data sources are cited appropriately throughout the text.

Assumptions and Findings

For this RFD scenario, we assume that, unless significant new oil and gas discoveries are made in the area, future activity will be primarily horizontal drilling for oil in the Mancos-Gallup play, with minor development targeted at natural gas production. We also assume that oil and natural gas prices will follow Energy Information Administration projections (Annual Energy Outlook, 2017).

Within the RMPA Planning Area, the RFD baseline scenario projects 3,200 new oil and gas wells (2,300 horizontal and 900 vertical or directional) for period 2018-2037. As of 2017, existing wells in the planning area were associated with 56,500 acres of surface disturbance. Over the life of the plan, the maximum potential disturbance (including existing and projected disturbance) is 75,000 acres. Accounting for reclamation, we expect for 43,000 acres of surface disturbance to remain at the end of the plan in 2037. Hydraulic fracturing of the projected wells will require an estimated 60 million barrels (2.5 billion gallons) of water. Over the life of the plan, the existing and projected wells will produce an estimated 279,561,000 barrels of oil, 5,083,680,000 thousand cubic feet (Mcf) of gas, and 187,223,000 barrels of water.

Historical Activity

A total of 37,307 wells have been drilled within the RMPA Planning Area through August 2017 (IHS Energy Group, 2017). The total figure includes 24,825 gas wells (67%), 2,249 oil wells (6%), 208 injection wells (0.5%), and 9,638 abandoned wells (26%). The remaining 387 wells (1%) consist of 3 carbon dioxide wells, 51 salt water disposal wells, 63 wells in pre-productive statuses (start, at total depth, and treated), and 270 wells in non-productive statuses (pilot, service, observation, suspended, and temporarily abandoned).

Annual drilling activity in the planning area is shown in **Figure 2**. Historically, the San Juan Basin has been dominated by vertical drilling for natural gas. Drilling for coalbed gas in the central basin took off in the late 1980s; the sharp spike in drilling in 1990, in which 1,248 wells were drilled, is from coalbed development. Horizontal drilling in the planning area has occurred sporadically since 1980, but began to increase sharply as a share of overall drilling in the mid-2000s. **Figure 3** shows the locations of all horizontal wells drilled within the Farmington Field Office.

Recent Drilling Activity

Figure 4 shows the locations of oil and gas wells drilled in the past ten years (2008-2017) within the Farmington Field Office. A total of 2,336 wells were drilled within the RMPA Planning Area boundary. The total figure includes 1,799 gas wells (77%), 293 oil wells (13%), 3 injection wells (0.1%), and 93 abandoned wells (4%). The remaining 148 wells (6%) consist of 2 carbon dioxide wells, 13 salt water disposal wells, 63 wells in pre-productive statuses (start, at total depth, and treated), and 70 wells in non-productive statuses (pilot, service, observation, suspended, and temporarily abandoned).

Horizontal drilling first accounted for greater than 10% of total drilling in the planning area in 2010. In 2014, drilling for oil (118 wells) surpassed drilling for gas (43 wells) for the first time. Horizontal drilling peaked in 2014, with 120 horizontal wells drilled (of which 102 were for oil). In 2017, horizontal drilling made up 77% of total development.

Oil and Gas Production

Supplemental Table A shows historical oil, natural gas, and water production for the RMPA Planning Area since 1973 (IHS Energy Group, 2018). Gas production increased sharply from 1991 to 1999, peaking at 1.1 billion Mcf in 1999. Gas production remained high through approximately 2007 and has declined through year-end 2017. Oil production gradually declined from 7,817,998 barrels in 1986 to 2,195,314 barrels in 2012 before rising sharply from 2012 to 2015, peaking at 8,457,418 barrels in 2015. Data are shown through year-end 2017.

Oil and Gas Prices

Historical and projected annual natural gas and oil prices are shown in **Figure 5**. Natural gas prices peaked at $8.86/Mcf in 2008 and oil prices peaked at $99.67/barrel in 2008. Drilling activity in the planning area (**Figure 2**) does not appear to correlate with the rise and fall of market prices. It is reasonable to assume that areas left undeveloped during the period of elevated prices (2000-2010) are unlikely to be developed unless either market prices meet or exceed those levels in the future, or technological advances result in significantly lower drilling and completion costs. For purposes of this RFD scenario, we assume natural gas and oil prices during the 2018-2037 planning period will align with the Energy Information Administration 2017 projections.

Pipelines and Facilities

Figure 6 shows the existing pipelines and facilities by owner within the Farmington Field Office administrative boundary (IHS Energy Group, 2017). The U.S. Energy Information Administration defines intrastate pipelines as pipelines that operate totally within state borders and link producers to local markets or to the interstate pipeline network. Conversely, interstate pipelines cross one or more state borders, connecting regional networks.

San Juan, McKinley, and Sandoval Counties have both intrastate and interstate oil pipelines. Intrastate and interstate gas pipelines exist in San Juan, McKinley, Sandoval, and Rio Arriba Counties. In San Juan County, the Bloomfield Terminal acts as a storage and shipping location for crude oil and petroleum products (New Mexico Oil Conservation Division, 2017). Western Refining operates an oil refinery in Gallup, New Mexico. The company also owns a natural gas liquids fractionation plant in Wingate, New Mexico, but the plant has been idle since 2014. Natural gas liquids pipelines connect the Gallup and Wingate plants in McKinley County, and also exist in San Juan, Rio Arriba, and Sandoval Counties. In producing gas fields, gas compressors are a necessary part of the infrastructure to move natural gas to market. The BLM anticipates no additional gas compressors in producing fields since the current infrastructure is expected to handle present and future gas demand. Unless the gas market performs significantly better than projected, no new major gas pipelines or facilities are expected to be needed in the planning area. Additional intrastate or interstate oil pipelines may be needed to move the projected oil volumes.

Occurrence Potential

Producing Formations

Oil and gas occur in numerous formations within the RMPA Planning Area, ranging in time from the Middle Jurassic to the Eocene. A chronostratigraphic chart for the San Juan Basin showing producing formations is presented in **Figure 7**. The chart is modified from the U.S. Geological Survey's assessment of the San Juan Basin from 2013. Formations that are predominantly oil-producing are shown in green, predominantly gas-producing in red, and formations that have produced both oil and gas are shown in purple (IHS Energy Group, 2017). Oil-producing intervals include the Jurassic San Rafael Group, including the Entrada Sandstone; and the Cretaceous Gallup Sandstone and Tocito Sandstone "lentils" within the Mancos Shale. Gas is found in the Jurassic Burro Canyon Formation; the Cretaceous Mesaverde Group, Lewis Shale, Pictured Cliffs Sandstone, and Fruitland Formation; and the Tertiary Ojo Alamo Sandstone, Nacimiento Formation, Animas Formation, and San Jose Formation. Formations that are known to produce both oil and gas include the Jurassic Morrison Formation, including the Brushy Basin Member; the Cretaceous Dakota Sandstone, and members of the Mancos Shale including the Graneros, Greenhorn Limestone, Juana Lopez, and El Vado Sandstone.

For more detail on the hydrocarbon potential and geological setting of the San Juan Basin, please refer to the geological discussions in Molenaar, 1987; USGS, 2013; and Broadhead, 2015. For a comprehensive geologic history of the region, we suggest *Geology of the American Southwest* (Baldridge, 2004).

Occurrence Potential—General

For the purposes of this document, "occurrence potential" is defined as "the geologic likelihood for oil and gas accumulations to exist in a given area," and does not account for economic factors or historical development trends. (See the "Projections of Future Activity" section of this document for analysis that incorporates these factors.)

We consider the RMPA Planning Area to have very high potential for the occurrence of oil and gas overall (**Figure 8**) and medium to very high potential for oil and gas that is likely to be developed by horizontal drilling (**Figure 9**). The USGS has defined multiple assessment units with oil and gas potential that encompass the planning area (San Juan Basin Assessment, 2013).

The BLM has established criteria for rating the oil and gas occurrence potential of lands studied for planning area documents. This rating system is based on guidance outlined in the Bureau of Land Management Handbook H-1624-1. The USGS assessment units within the Planning Area were classified using a number of geologic characteristics that qualify them as having high occurrence potential:

- presence of hydrocarbon source rocks
- presence of reservoir rocks with adequate porosity/permeability
- potential for structural/stratigraphic traps to exist
- opportunity for migration from source to trap, and
- favorable temperature, depth of burial, and subsurface pressure conditions.

Table 2. Rating system for hydrocarbon occurrence potential.

Occurrence Potential	Explanation
Very High	Within two or more overlapping USGS Assessment Units
High	Within one USGS Assessment Unit
Medium	Outside of USGS Assessment Units, but conditions for hydrocarbon accumulation may exist
None	Intrusive igneous rocks outcrop at surface. Conditions for hydrocarbon accumulation do not exist

Occurrence Potential—For Horizontally-Developed Plays

As discussed in the "Historical Activity" section of this document, horizontal drilling has increased as a fraction of total drilling since the mid-2000s, and we project the trend to continue over the life of the plan. As such, we have generated a map (**Figure 9**) that focuses on oil and gas plays that are likely to be developed horizontally based on past drilling activity. Please note that the criteria used to generate this map (described in **Table 3**, below) are different from the criteria used to generate the general occurrence potential map (**Table 2** for criteria, **Figure 8** for map).

USGS plays were identified as having major or moderate existing horizontal development using the "Play Name" attribute in well data from IHS (IHS Energy, 2017). The plays with major existing horizontal development (more than 50 wells) were the Mancos, the Fruitland, and the Pictured Cliffs. The plays with moderate existing horizontal development (five to twenty wells) were the Dakota, the Lewis, the Mesaverde, and Point Lookout. Plays with fewer than five existing horizontal wells were not considered likely candidates for future horizontal development.

Table 3. Rating system for occurrence potential for horizontally-developed plays.

Occurrence Potential for Horizontal Development	Explanation
Very High	Within two or more major horizontal plays
High	Within one major horizontal play
Medium	Within no major horizontal plays, but within one or more moderate horizontal plays
Low	Outside of major and moderate horizontal plays
None	Intrusive igneous rocks outcrop at surface. Conditions for hydrocarbon accumulation do not exist

Projections of Future Activity

Development Potential

Figure 10 shows the development potential (location and intensity of projected development) for the RMPA Planning Area. This information is also summarized in **Table 4**, below.

Table 4. Development potential summary for the RMPA Planning Area.

Development Potential	Acres in Planning Area	Wells per Township	Type of Development
Negligible	249,400	< 1	Likely vertical
Low	1,810,000	4-8	Likely vertical
Medium	1,635,000	6-9	Likely horizontal
High	273,000	10+	Likely horizontal

Historic drilling trends, geologic assessments, and recent indications of interest from industry were incorporated to determine where future development activities would likely occur. Indications of interest from industry include locations for applications for permit to drill (APDs), expressions of interest for leasing (EOIs), and proposed and recently-approved unitization agreements.

Development projections were only made for those lands within the Mancos-Gallup RMPA Planning Area that could potentially be available for leasing. This baseline scenario assumes all potentially productive areas within the planning area can be open under standard lease terms and conditions, except those areas designated as closed to leasing by law, regulation, or executive order.

Future Drilling

For the baseline development scenario, we estimate that during the 2018-2037 planning period, 2,300 horizontal wells and 900 vertical wells may be drilled in the RMPA Planning Area. The majority of horizontal drilling is expected to occur in the area of high development potential near Nageezi and is expected to target the Mancos-Gallup play. Development in the area of medium development potential to the south and west of the high potential area is also expected to target the Mancos-Gallup. The medium development potential area in the north central part of the planning area is anticipated to have more varied target formations; recent horizontal development has targeted the Fruitland, Mancos, and Pictured Cliffs, while recent vertical development has targeted the Dakota, Fruitland, Mancos, Morrison, Pictured Cliffs, and Point Lookout. The low development potential area has had fewer than 50 wells spudded per year since 2009 (compared to over 250 wells per year from 1979 to 1981), and recent development has been largely vertical drilling targeting the Dakota, Fruitland, Mancos, and Mesaverde. In the negligible development potential area, a total of four wells (all vertical) have been drilled since 2008. For the low and minimal development potential areas, we anticipate the trends of low overall levels of development to continue throughout the planning period.

Estimated Future Oil and Gas Production

Supplemental Table B represents our baseline estimates for cumulative annual production volumes for oil and gas within the RMPA Planning Area for period 2018-2037. We estimated the future yearly oil and gas production values by generating decline curves for vertical and horizontal wells from historical production data in the planning area and then convolving those production curves with the forecasted well counts. These estimates include both production from existing wells and production from predicted wells. Over the 20-year period, we predict a total of 279,561,000 barrels of oil; 5,083,680,000 thousand cubic feet of gas; and 187,223,000 barrels of water to be produced.

Estimated Surface Disturbance

Table 5 (next page) presents our estimates of surface disturbance associated with the baseline projections for the period 2018-2037. In 2017, there were approximately 56,500 acres of existing disturbance associated with oil and gas development. For period 2018-2037, we estimate an additional 18,500 acres of disturbance, which includes both new wells and new disturbance on existing well pads, for a maximum potential disturbance of 75,000 acres.

Accounting for interim and final reclamation, we expect 43,000 acres of surface disturbance to remain at the end of the plan.

Table 5. Summary of estimated surface disturbance, 2018-2037.

Surface Disturbance Category	Acres
Existing Disturbance, 2017	56,500
New Disturbance, 2018 to 2037	18,500
Maximum Potential Disturbance (New + Existing)	75,000
Interim and Final Reclamation, 2018 to 2037	32,000
Disturbance Remaining at End of Plan (Maximum - Reclamation)	43,000

For more details on estimating existing and additional surface disturbance, please refer to **Supplemental Table C** and **Supplemental Table D.** Acreage estimates for roads, flow lines, and well pads come from Farmington Field Office staff (Sarah Scott, personal communication, 2018).

Estimated Water Use for Hydraulic Fracturing

Within the RMPA Planning Area, we estimate that hydraulically fracturing the wells projected for period 2018-2037 will require 2.5 billion gallons (7,683 acre-feet) of water over the 20-year period.

These estimates assume that 100% of wells will be hydraulically fractured, and do not account for re-use or recycling of hydraulic fracturing fluid. Fracturing fewer wells and/or re-using or recycling hydraulic fracturing fluid would reduce these volumes.

Statistics for water volumes used for hydraulic fracturing in the San Juan Basin come from the New Mexico Bureau of Geology and Mineral Resources' hydrologic assessment of oil and gas development in the San Juan Basin (Kelley, 2014) and from the U.S. Environmental Protection Agency's assessment of impacts from hydraulic fracturing on drinking water resources (U.S. Environmental Protection Agency, 2016). Mean water volumes for vertical and directional wells in the San Juan Basin vary by formation and range from 105,000 gallons per well (Dakota formation; Kelley, 2014) to 207,000 gallons per well (Gallup formation; Kelley, 2014). EPA data and other formations discussed in the Kelley assessment fall within this range. The mean water volume for fracturing horizontal wells in the San Juan Basin was 1,020,000 gallons per well (not differentiated by formation; Kelley, 2014). This figure does not control for the length of the fractured interval and could increase as longer laterals are drilled.

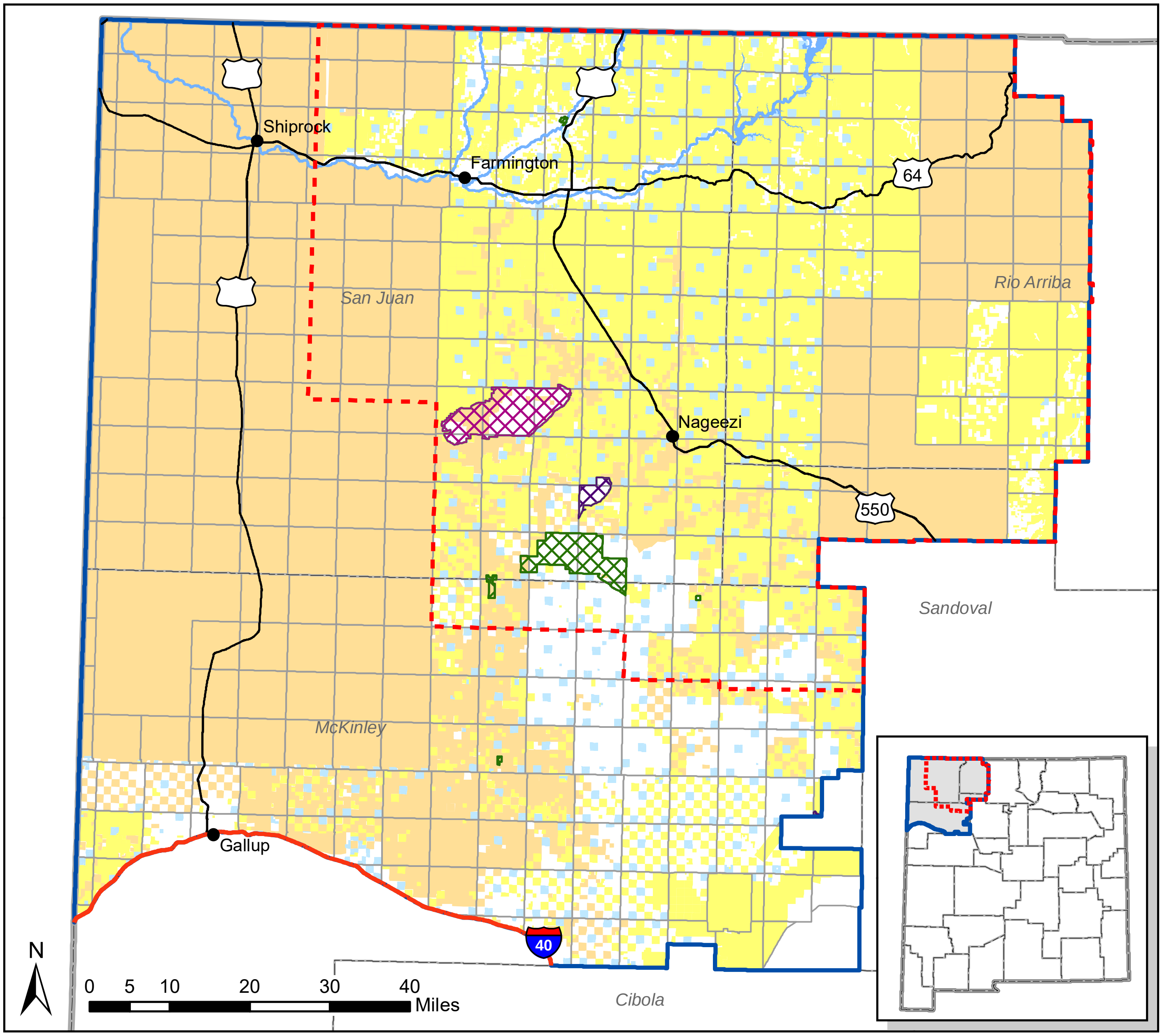
Summary

We examined the available information on the Mancos-Gallup Resource Management Plan Amendment Planning Area within the Farmington Field Office administrative boundary (geologic reports, recent drilling data, indications of industry interest, and professional knowledge of the area) and used that data to prepare a map that indicates areas of potential oil and gas development for 2018-2037 (**Figure 10**). We also estimated the number of wells that could be drilled during this period, as well as the disturbance associated with projected and existing wells over the life of the plan. We estimated that 3,200 wells (2,300 horizontal and 900 vertical) may be reasonably assumed to be drilled. Within the planning area, the maximum potential surface disturbance over the life of the plan is 75,000 acres, and we project 43,000 acres of disturbance to remain by 2037.

Figure 1. Oil and Gas Minerals within the Farmington Field Office Administrative Boundary

Kelsey Crocker, GIS Specialist
James Glover, Geologist
Farmington Field Office RMPA
February 2018

Oil and gas mineral ownership and status (available or unavailable for leasing).



Explanation

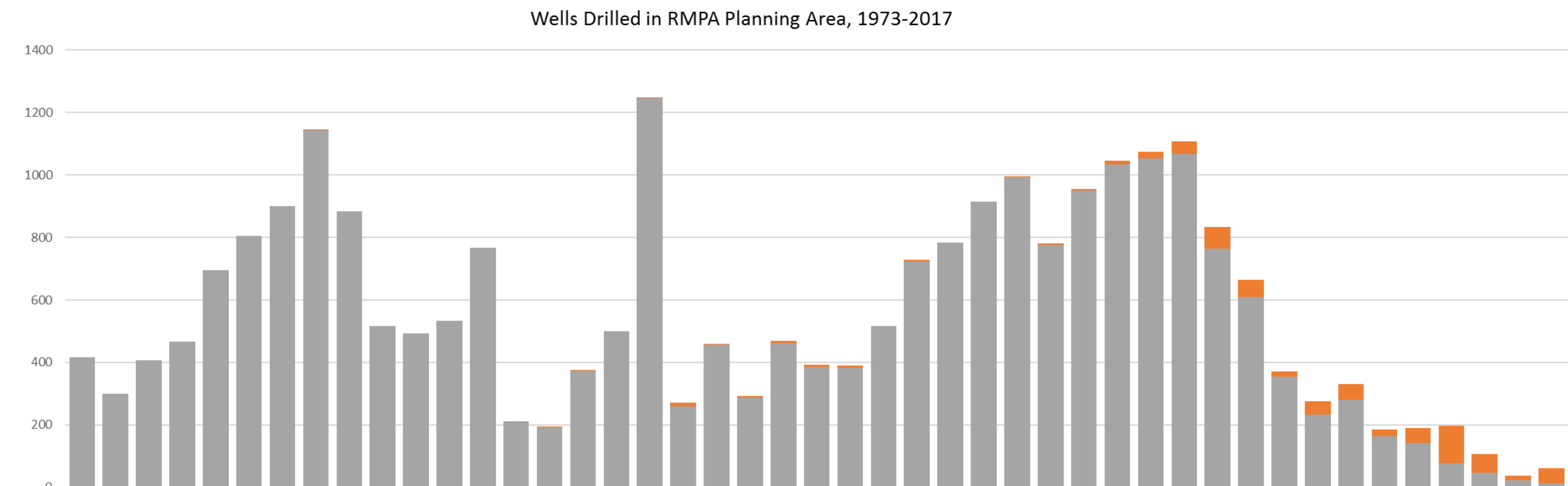
- RMPA Planning Area
- FFO Administrative Boundary
- BLM-Managed Oil and Gas Minerals Potentially Open to Leasing
- Indian Minerals (Allotted and Tribal)
- State Minerals

Unavailable for Fluid Leasing

- National Park Service Boundaries
- Wilderness Areas
- Wilderness Study Areas

NAD 1983 Albers
False Easting: 0.0
False Northing: 0.0
Central Meridian: -106.0
Standard Parallel 1: 33.0
Standard Parallel 2: 36.0
Latitude of Origin: 34.5
Linear Unit: Meter

Figure 2. Wells drilled within the RMPA Planning Area, 1973-2017 (IHS Energy Group, 2017).



	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Horizontal	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Vertical & Directional	416	299	406	466	695	804	901	1144	883	517	493	534	766	211	192

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Horizontal	2	0	2	12	1	5	9	7	6	0	6	0	0	1	5
Vertical & Directional	374	500	1246	258	458	287	461	385	384	517	723	783	915	994	777

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Horizontal	4	11	23	40	68	56	15	44	51	22	49	120	61	15	48
Vertical & Directional	951	1034	1052	1068	765	609	355	233	280	163	142	77	46	23	14

Figure 3. All Horizontal Wells within the Farmington Field Office Administrative Boundary

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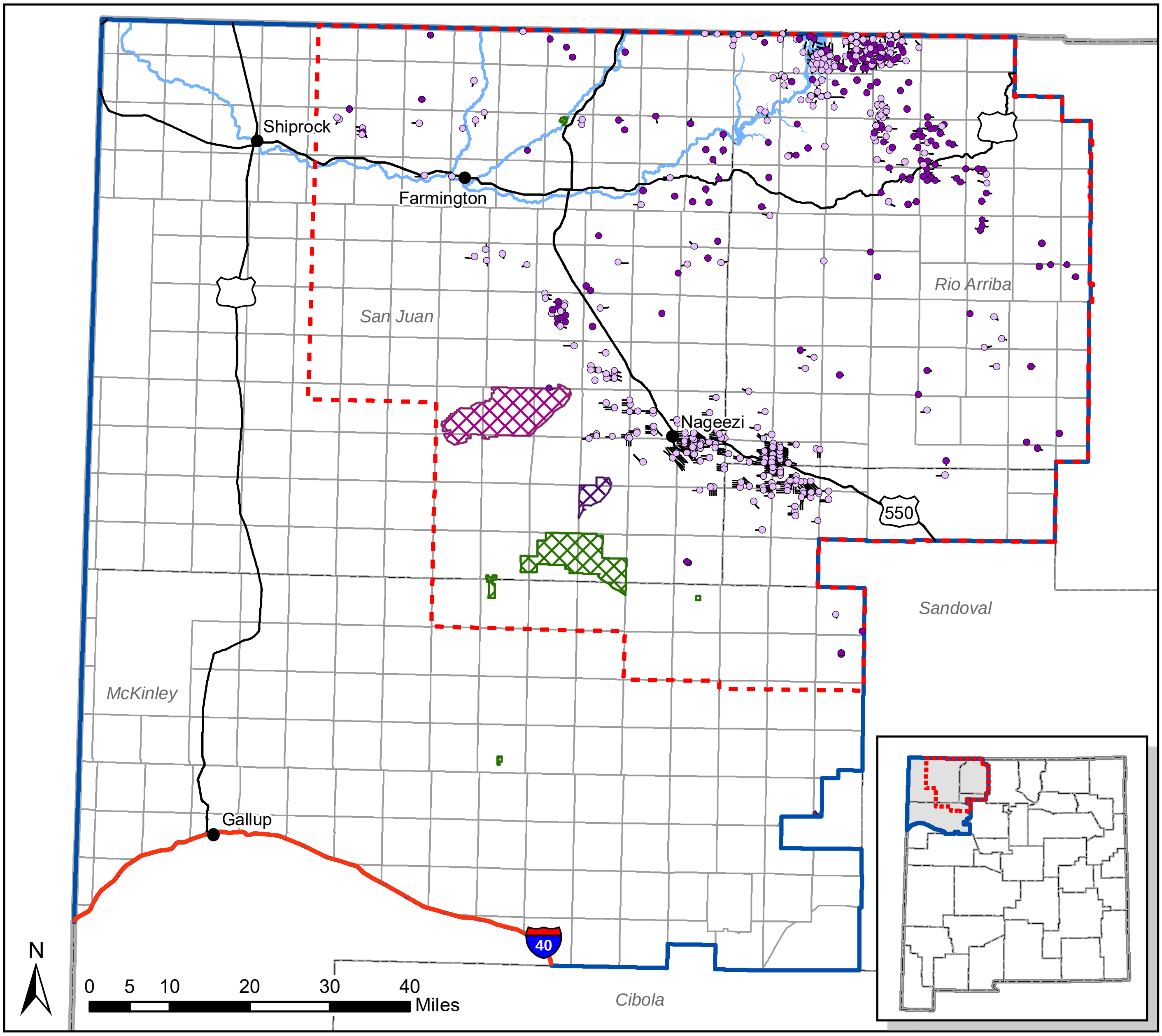
James Glover, Geologist
Farmington Field Office RMPA
February 2018

All horizontal wells (first horizontal well drilled in 1980)



Horizontal Wells 1980 - 2017

- Wells Drilled 1980 - 2007
- Wells Drilled 2008 - 2017
- Well Bores

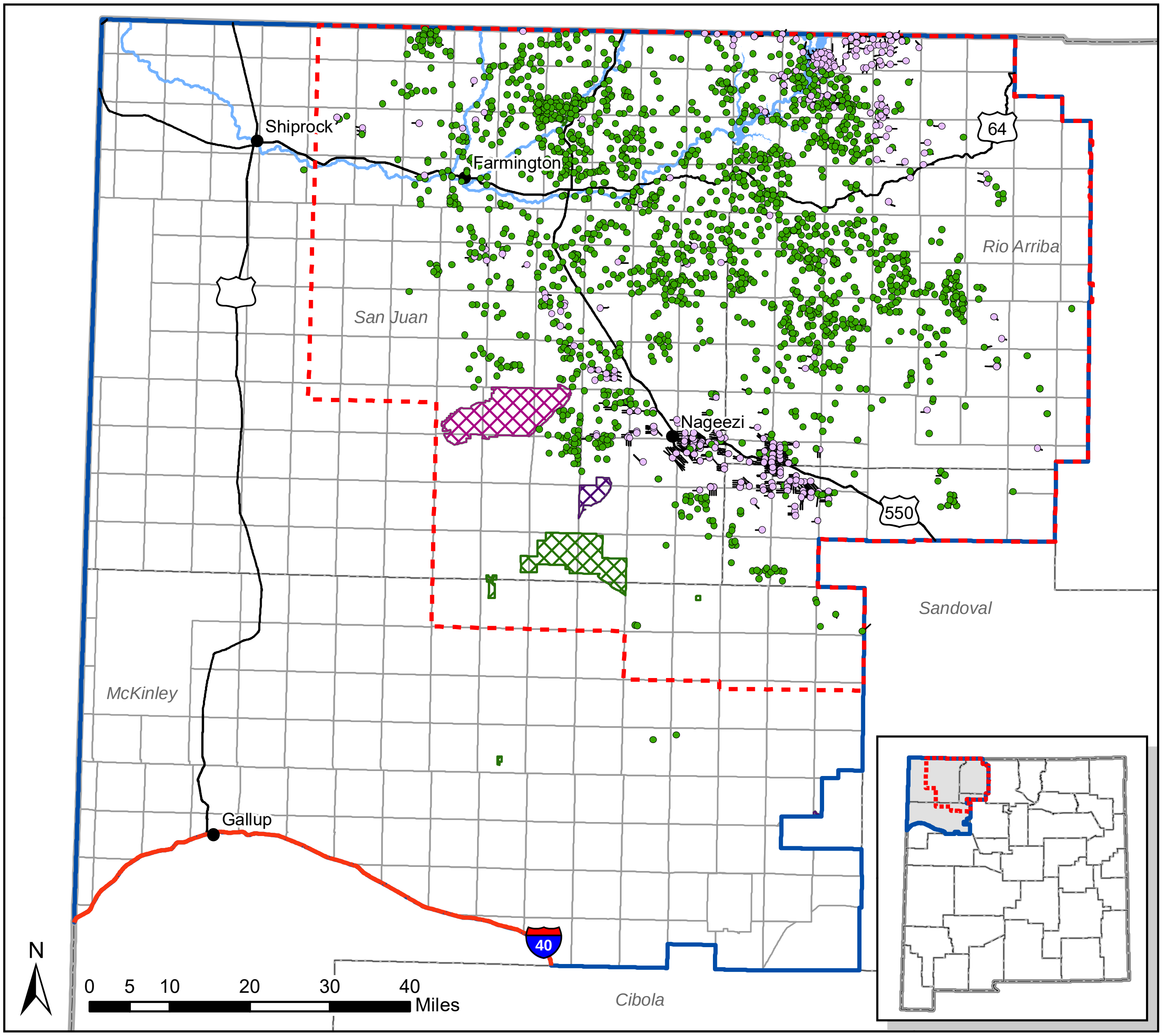
RMPA Planning Area
FFO Administrative Boundary
National Park Service Boundaries
Wilderness Areas
Wilderness Study Areas

NAD 1983 Albers
False Easting: 0.0
False Northing: 0.0
Central Meridian: -106.0
Standard Parallel 1: 33.0
Standard Parallel 2: 36.0
Latitude of Origin: 34.5
Linear Unit: Meter

Figure 4. Recent Oil and Gas Wells within the Farmington Field Office Administrative Boundary

Kelsey Crocker, GIS Specialist
James Glover, Geologist
Farmington Field Office RMPA
February 2018

All wells drilled between 2008 and 2017



Wells Drilled Since 2008

- Vertical and Directional Wells
- Horizontal Wells
- Well Bores

RMPA Planning Area
FFO Administrative Boundary
National Park Service Boundaries
Wilderness Areas
Wilderness Study Areas

NAD 1983 Albers
False Easting: 0.0
False Northing: 0.0
Central Meridian: -106.0
Standard Parallel 1: 33.0
Standard Parallel 2: 36.0
Latitude of Origin: 34.5
Linear Unit: Meter

Figure 5. Historical and projected U.S. natural gas and oil prices, 1970-2040 (Energy Information Administration, 2017).

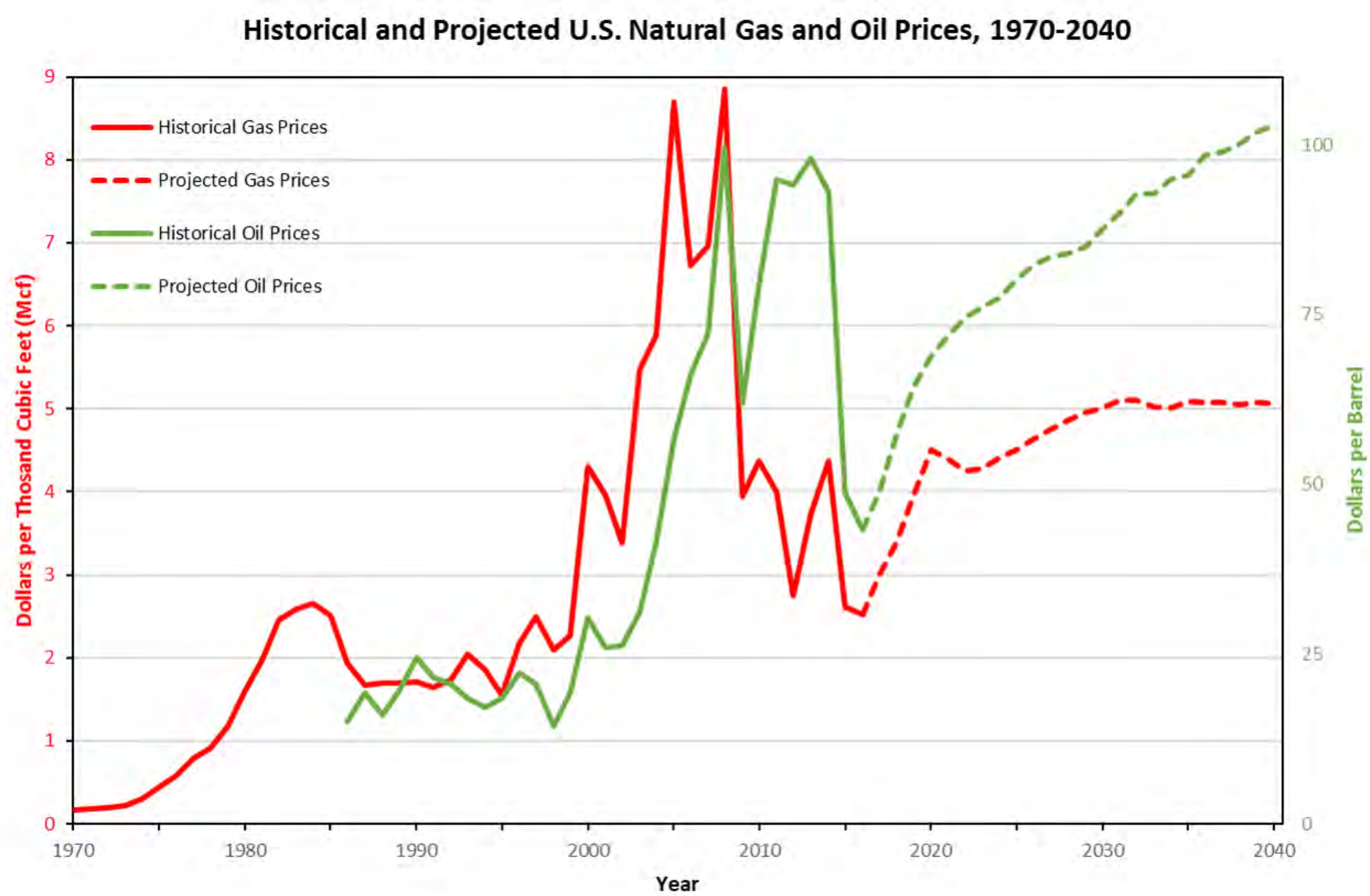
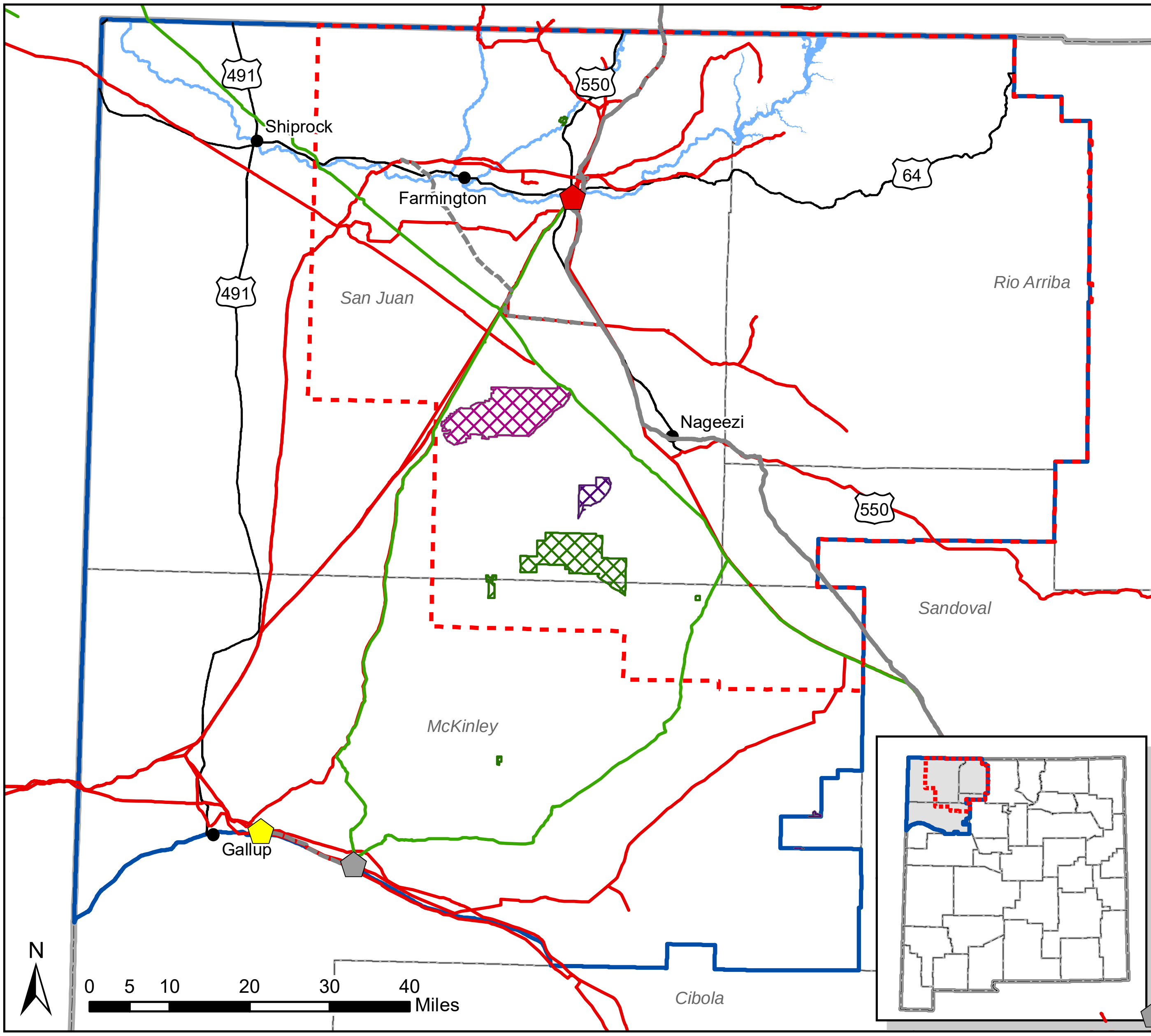


Figure 6. Pipelines and Facilities within the Farmington Field Office Administrative Boundary

Kelsey Crocker, GIS Specialist
James Glover, Geologist
Farmington Field Office RMPA
February 2018



Pipelines and Facilities

- Oil Pipelines
- Gas Pipelines
- Natural Gas Liquids Pipelines
- Bloomfield Terminal
- Gallup Refinery
- Wingate Fractionation Plant (idled 2014)

- RMPA Planning Area
- FFO Administrative Boundary
- National Park Service Boundaries
- Wilderness Areas
- Wilderness Study Areas

NAD 1983 Albers
False Easting: 0.0
False Northing: 0.0
Central Meridian: -106.0
Standard Parallel 1: 33.0
Standard_Parallel 2: 36.0
Latitude of Origin: 34.5
Linear Unit: Meter

Figure 7. Chart showing regional chronostratigraphic correlations in the San Juan Basin with formations that are predominantly oil-producing, gas-producing, or mixed oil/gas-producing formations. This chart is modified from the U.S. Geological Survey's assessment of the San Juan Basin (U.S. Geological Survey San Juan Basin Assessment Team, 2013). Vertical lines are unconformities. Production information is from IHS Energy Group, 2017.

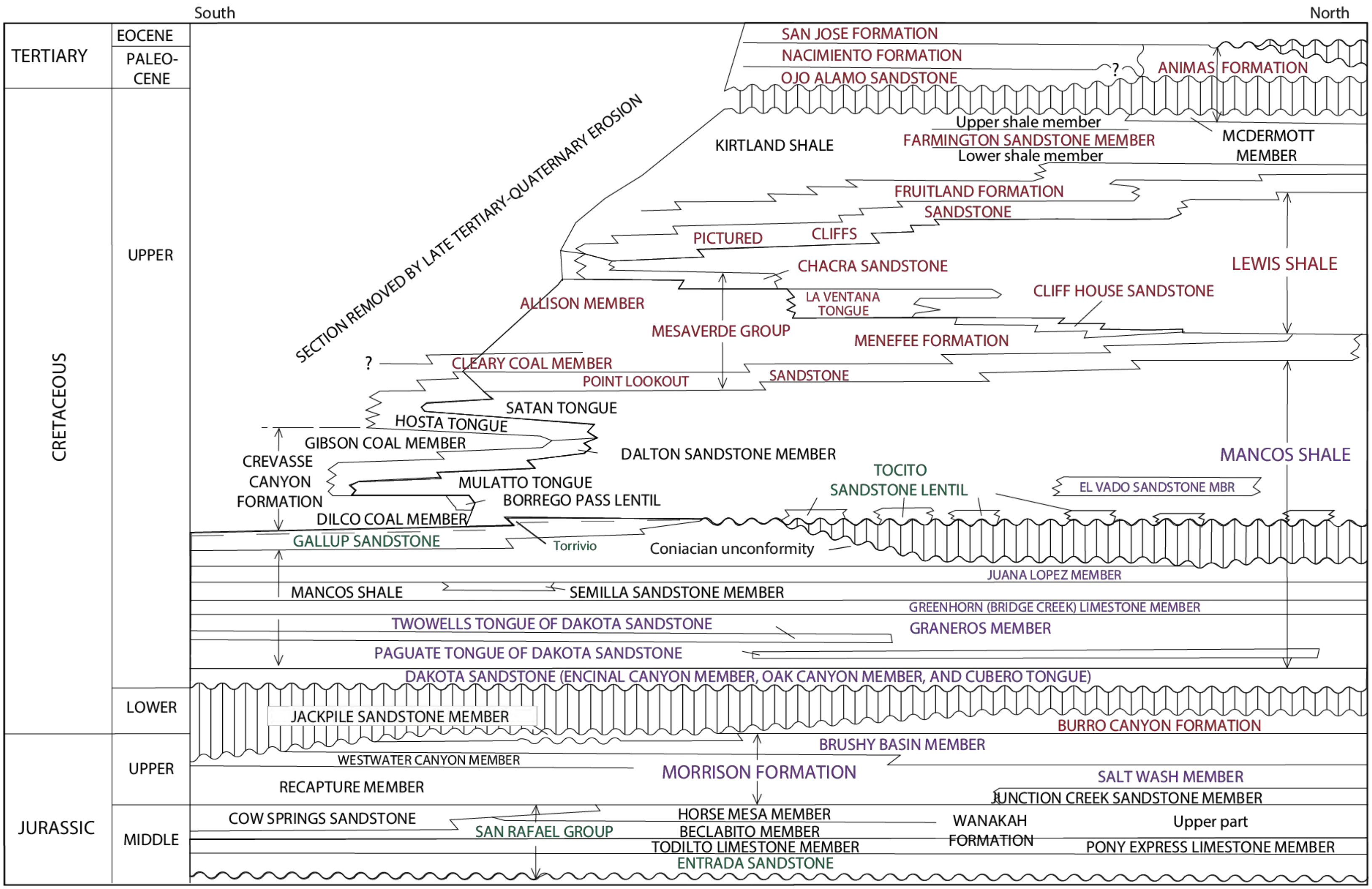


Figure 8. Oil and Gas Occurrence Potential within the Farmington Field Office Administrative Boundary

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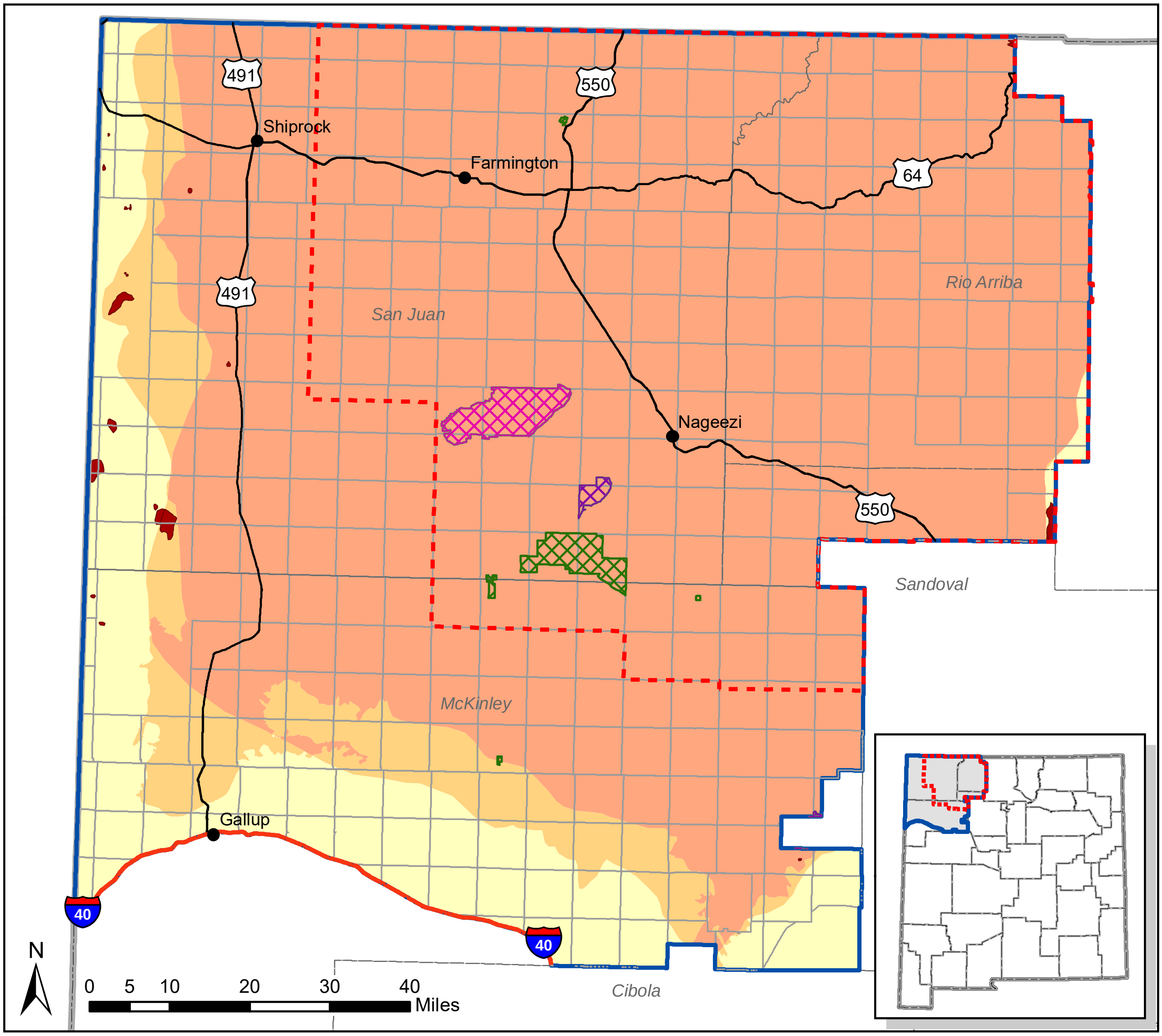
James Glover, Geologist
Farmington Field Office RMPA
February 2018

All plays combined



Occurrence Potential

- None - crystalline rock
- Medium
- High
- Very High

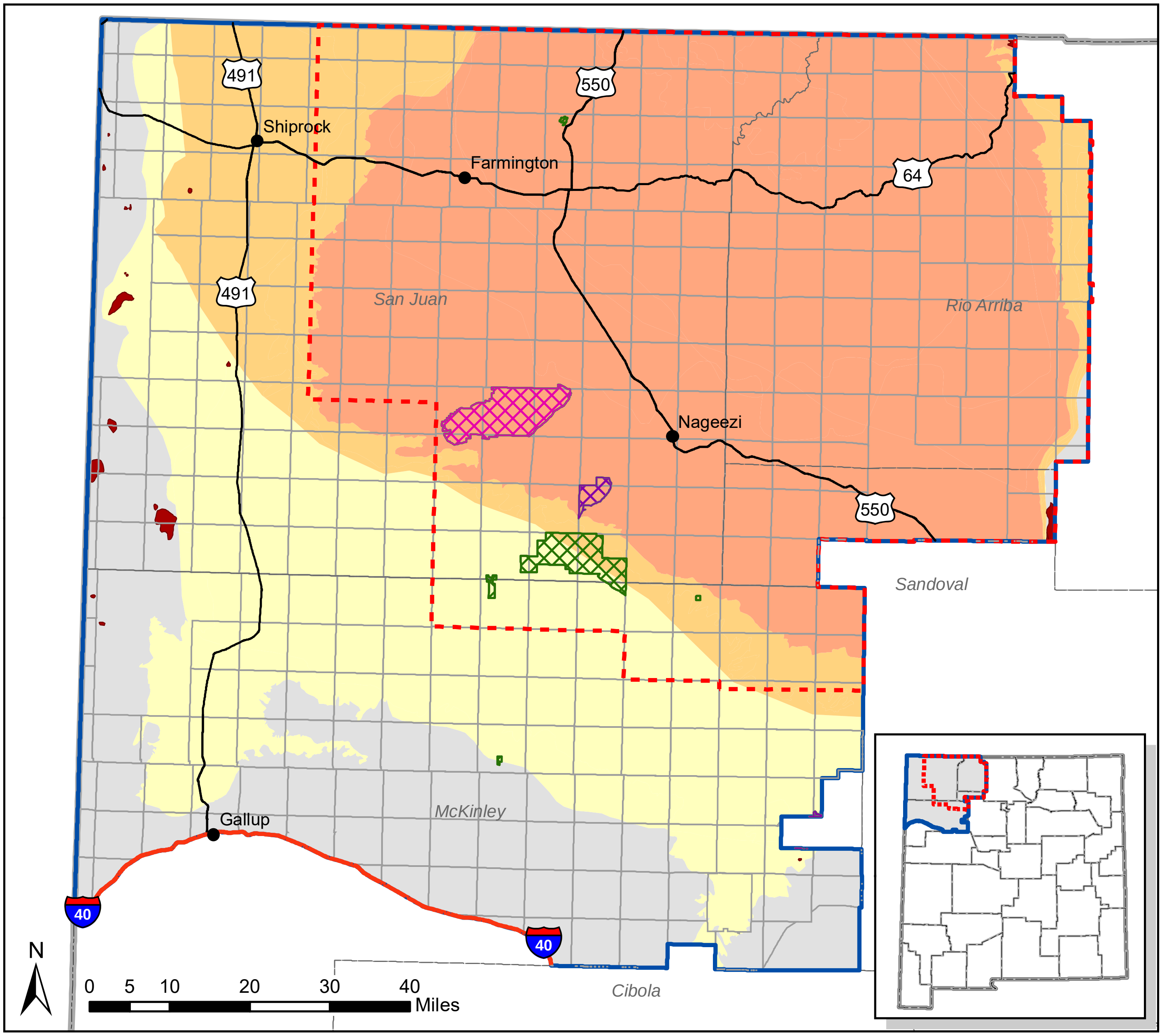
- RMPA Planning Area
- FFO Administrative Boundary
- National Park Service Boundaries
- Wilderness Areas
- Wilderness Study Areas

NAD 1983 Albers
False Easting: 0.0
False Northing: 0.0
Central Meridian: -106.0
Standard Parallel 1: 33.0
Standard Parallel 2: 36.0
Latitude of Origin: 34.5
Linear Unit: Meter

Figure 9. Oil and Gas Occurrence Potential within the Farmington Field Office Administrative Boundary

Kelsey Crocker, GIS Specialist
James Glover, Geologist
Farmington Field Office RMPA
February 2018

For horizontally-developed plays



Occurrence Potential for Horizontal Development

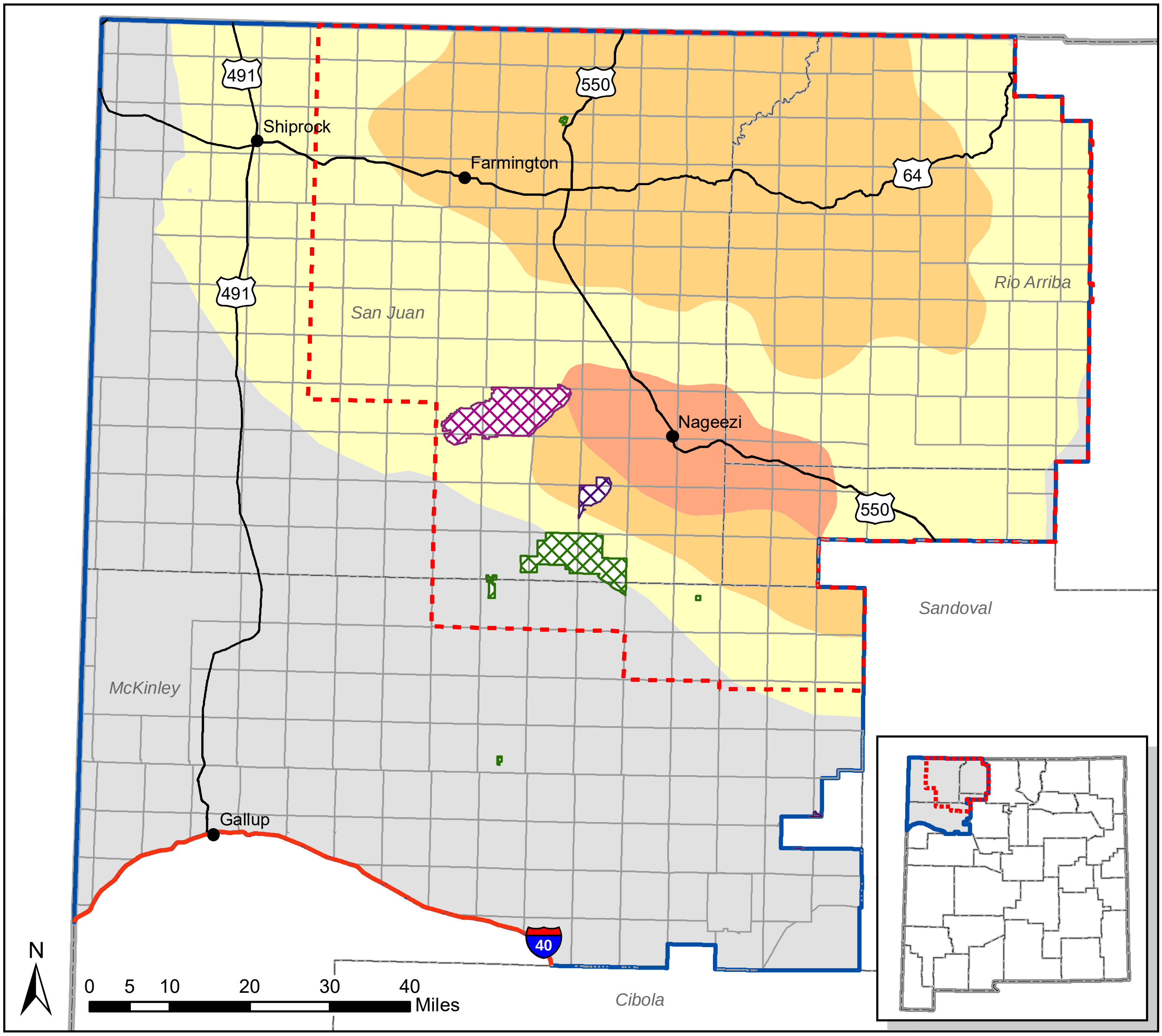
- None - crystalline rock
- Low
- Medium
- High
- Very High

- RMPA Planning Area
- FFO Administrative Boundary
- National Park Service Boundaries
- Wilderness Areas
- Wilderness Study Areas

NAD 1983 Albers
False Easting: 0.0
False Northing: 0.0
Central Meridian: -106.0
Standard Parallel 1: 33.0
Standard Parallel 2: 36.0
Latitude of Origin: 34.5
Linear Unit: Meter

Figure 10. Oil and Gas Development Potential within the Farmington Field Office Administrative Boundary, 2018-2037

Kelsey Crocker, GIS Specialist
James Glover, Geologist
Farmington Field Office RMPA
February 2018



Development Potential

- Negligible (<1 well per township, likely vertical)
- Low (4-8 wells per township, likely vertical)
- Medium (6-9 wells per township, likely horizontal)
- High (10+ wells per township, likely horizontal)

- RMPA Planning Area
- FFO Admin. Boundary
- National Park Service Boundaries
- Wilderness Areas
- Wilderness Study Areas

NAD 1983 Albers
False Easting: 0.0
False Northing: 0.0
Central Meridian: -106.0
Standard Parallel 1: 33.0
Standard Parallel 2: 36.0
Latitude of Origin: 34.5
Linear Unit: Meter

Areas closed to leasing by statute are not analyzed for development potential.

Supplemental Tables

Supplemental Table A. Historical oil, gas, and water production from the Mancos-Gallup RMPA Planning Area, 1973-2017. Cumulative volumes are from 1973 forward.

Year	Oil (bbl)		Gas (Mcf)		Water (bbl)	
	ANNUAL	CUM	ANNUAL	CUM	ANNUAL	CUM
1973	5,716,800	5,716,800	531,287,668	531,287,668	10,324,391	10,324,391
1974	5,236,789	10,953,589	525,904,604	1,057,192,272	14,769,943	25,094,334
1975	4,495,723	15,449,312	497,517,602	1,554,709,874	13,721,771	38,816,105
1976	4,582,245	20,031,557	509,967,363	2,064,677,237	15,896,985	54,713,090
1977	4,787,130	24,818,687	516,087,877	2,580,765,114	19,962,508	74,675,598
1978	5,073,495	29,892,182	526,237,398	3,107,002,512	27,213,876	101,889,474
1979	5,349,084	35,241,266	550,930,908	3,657,933,420	31,253,586	133,143,060
1980	5,374,917	40,616,183	553,419,713	4,211,353,133	33,303,987	166,447,047
1981	6,213,383	46,829,566	544,379,563	4,755,732,696	37,299,198	203,746,245
1982	5,771,394	52,600,960	450,286,390	5,206,019,086	36,995,593	240,741,838
1983	5,885,364	58,486,324	384,564,540	5,590,583,626	35,651,214	276,393,052
1984	6,836,401	65,322,725	424,727,288	6,015,310,914	35,575,650	311,968,702
1985	7,420,594	72,743,319	419,577,756	6,434,888,670	46,674,111	358,642,813
1986	7,817,998	80,561,317	303,053,821	6,737,942,491	27,666,349	386,309,162
1987	7,357,362	87,918,679	381,101,246	7,119,043,737	26,210,387	412,519,549
1988	6,524,802	94,443,481	359,787,979	7,478,831,716	25,476,580	437,996,129
1989	6,239,870	100,683,351	413,222,483	7,892,054,199	29,826,262	467,822,391
1990	5,221,494	105,904,845	498,102,640	8,390,156,839	41,334,768	509,157,159
1991	4,468,025	110,372,870	543,249,967	8,933,406,806	39,788,923	548,946,082
1992	4,758,817	115,131,687	747,970,801	9,681,377,607	32,959,423	581,905,505
1993	4,480,318	119,612,005	897,879,103	10,579,256,710	31,528,469	613,433,974
1994	4,149,299	123,761,304	950,964,342	11,530,221,052	22,790,154	636,224,128
1995	3,863,079	127,624,383	991,282,475	12,521,503,527	27,406,814	663,630,942
1996	3,737,614	131,361,997	1,032,946,096	13,554,449,623	29,106,512	692,737,454
1997	3,527,475	134,889,472	1,048,412,673	14,602,862,296	30,500,370	723,237,824
1998	3,123,784	138,013,256	1,073,319,014	15,676,181,310	27,238,632	750,476,456
1999	3,020,326	141,033,582	1,107,058,650	16,783,239,960	20,817,132	771,293,588
2000	2,990,259	144,023,841	1,080,591,791	17,863,831,751	22,184,310	793,477,898
2001	2,811,017	146,834,858	1,023,338,343	18,887,170,094	22,624,225	816,102,123
2002	2,676,747	149,511,605	968,929,539	19,856,099,633	21,470,799	837,572,922
2003	2,561,962	152,073,567	946,806,293	20,802,905,926	24,019,135	861,592,057
2004	2,409,369	154,482,936	964,134,462	21,767,040,388	25,020,444	886,612,501
2005	2,378,542	156,861,478	958,487,109	22,725,527,497	25,861,523	912,474,024
2006	2,363,695	159,225,173	963,917,906	23,689,445,403	28,167,260	940,641,284

(continued on next page)

Supplemental Table A, continued. Historical oil, gas, and water production from the Mancos-Gallup RMPA Planning Area, 1973-2017 (IHS Energy Group, 2018). Cumulative volumes are from 1973 forward.

Year	Oil (bbl)		Gas (Mcf)		Water (bbl)	
	ANNUAL	CUM	ANNUAL	CUM	ANNUAL	CUM
2007	2,266,600	161,491,773	935,226,410	24,624,671,813	34,468,372	975,109,656
2008	2,284,345	163,776,118	896,186,332	25,520,858,145	35,425,669	1,010,535,325
2009	2,230,399	166,006,517	864,801,616	26,385,659,761	37,435,679	1,047,971,004
2010	2,015,139	168,021,656	804,541,980	27,190,201,741	39,083,011	1,087,054,015
2011	2,103,028	170,124,684	775,975,741	27,966,177,482	39,607,511	1,126,661,526
2012	2,195,314	172,319,998	741,575,511	28,707,752,993	39,920,867	1,166,582,393
2013	2,912,460	175,232,458	687,349,503	29,395,102,496	37,704,475	1,204,286,868
2014	5,754,767	180,987,225	664,211,261	30,059,313,757	42,362,511	1,246,649,379
2015	8,457,418	189,444,643	642,442,712	30,701,756,469	39,180,438	1,285,829,817
2016	6,888,791	196,333,434	596,747,304	31,298,503,773	33,757,377	1,319,587,194
2017	5,979,536	202,312,970	464,709,385	31,763,213,158	17,068,297	1,336,655,491

Supplemental Table B. Projected oil, natural gas, and water production from the Mancos-Gallup RMPA Planning Area, 2018-2037.

Year	Projected wells	Oil (bbl)		Gas (Mcf)		Water (bbl)	
		ANNUAL	CUM	ANNUAL	CUM	ANNUAL	CUM
2018	67	7,728,000	7,728,000	378,604,000	378,604,000	9,405,000	9,405,000
2019	76	8,405,000	16,133,000	313,271,000	691,875,000	5,744,000	15,149,000
2020	86	8,954,000	25,087,000	265,002,000	956,877,000	4,453,000	19,602,000
2021	96	9,528,000	34,615,000	231,152,000	1,188,029,000	4,164,000	23,766,000
2022	106	10,063,000	44,678,000	208,659,000	1,396,688,000	4,340,000	28,106,000
2023	116	10,583,000	55,261,000	197,789,000	1,594,477,000	4,919,000	33,025,000
2024	126	11,145,000	66,406,000	191,704,000	1,786,181,000	5,564,000	38,589,000
2025	136	11,762,000	78,168,000	189,422,000	1,975,603,000	6,281,000	44,870,000
2026	146	12,429,000	90,597,000	191,739,000	2,167,342,000	7,052,000	51,922,000
2027	156	13,140,000	103,737,000	197,594,000	2,364,936,000	7,888,000	59,810,000
2028	166	13,932,000	117,669,000	206,544,000	2,571,480,000	8,687,000	68,497,000
2029	176	14,739,000	132,408,000	217,656,000	2,789,136,000	9,518,000	78,015,000
2030	180	14,499,000	146,907,000	229,086,000	3,018,222,000	10,328,000	88,343,000
2031	194	16,006,000	162,913,000	244,381,000	3,262,603,000	11,294,000	99,637,000
2032	204	17,024,000	179,937,000	260,365,000	3,522,968,000	12,108,000	111,745,000
2033	214	17,974,000	197,911,000	276,518,000	3,799,486,000	13,120,000	124,865,000
2034	224	18,965,000	216,876,000	293,654,000	4,093,140,000	14,116,000	138,981,000
2035	234	19,942,000	236,818,000	310,443,000	4,403,583,000	15,077,000	154,058,000
2036	244	20,897,000	257,715,000	330,313,000	4,733,896,000	16,094,000	170,152,000
2037	253	21,846,000	279,561,000	349,784,000	5,083,680,000	17,071,000	187,223,000

Supplemental Table C. Estimated surface disturbance in 2017 from existing wells.

	Well Count	**Pad Count**	**Roads & Flow Lines per pad (ac.)**	**Well Pad after interim rec. (ac.)**	**Total acres**
Existing horizontal wells (avg. 2 wells/pad)	557	279	0.6	2.5	865
Existing vertical wells	26,517	26,517	0.6	1.5	55,685
Totals	**27,074**	**26,796**	--	--	**56,550**

Supplemental Table D. New surface disturbance over the life of the plan (2018-2037).

	Well Count	**Pad Count**	**Roads & Flow Lines per pad (ac.)**	**Well Pad (ac.)**	**Total acres**
Projected horizontal wells (avg. 2 wells/pad)	2,300	1,150	0.6	6.25	7,878
Projected vertical wells	900	900	0.6	3.75	3,195
Existing horizontal wells (avg. 2 wells/pad)	557	279	0	0.25	70
Existing vertical wells	26,517	26,517	0	0.25	6,629
Totals	**30,274**	**28,846**	**--**	**--**	**18,492**

References

Baldridge, W.S., 2014, Geology of the American Southwest: A Journey through Two Billion Years of Plate-Tectonic History*,* Cambridge University Press, print.

Broadhead, R.F., 2015, The Upper Mancos Shale in the San Juan Basin: Three plays, Conventional and Unconventional: West Texas Geological Society 2015 Fall Symposium, available at http://www.searchanddiscovery.com/documents/2015/10791broadhead/ndx_broadhead.pdf

Engler, T.W., 2014, Reasonable Foreseeable Development (RFD) for Northern New Mexico—Final Report: New Mexico Institute of Mining and Technology, available at https://eplanning.blm.gov/epl-front-office/projects/lup/68107/86639/103810/SJB_Mancos_RFD_final_report-10.27.pdf

Engler, T.W., 2015, Update for Reasonable Foreseeable Development (RFD) for Northern New Mexico—Update Report: New Mexico Institute of Mining and Technology.

Gallegos, T.J., and Varela, B.A., 2015, Data regarding hydraulic fracturing distributions and treatment fluids, additives, proppants, and water volumes applied to wells drilled in the United States from 1947 through 2010: U.S. Geological Survey Data Series 868, 11 p., available at https://dx.doi.org/10.3133/ds868

Hedayati, T.S., 2008, Reservoir Trends and Exploration Potential of the El Vado Sandstone Member of the Mancos Shale, Northwestern New Mexico: Master's thesis, University of Texas, Austin, available at https://repositories.lib.utexas.edu/handle/2152/47199

IHS Energy Group, 2017, U.S. Well Data, IHS Enerdeq Browser, v7.

Kelley, S., et al., 2014, Hydrologic Assessment of Oil and Gas Resource Development of the Mancos Shale in the San Juan Basin, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open File Report 566, available at https://eplanning.blm.gov/epl-front-office/projects/lup/68107/86635/103806/2014.11.24_BLM_final_hydrology_report.pdf

Molenaar, C.M., 1987, Petroleum geology and hydrocarbon plays of the Albuquerque-San Luis rift basin, New Mexico and Colorado: U.S. Geological Survey Numbered Series 87-450-S, available at https://pubs.er.usgs.gov/publication/ofr87450S

New Mexico Oil Conservation Division, 2017, OCD Discharge Permit for Bloomfield Terminal, available at http://www.emnrd.state.nm.us/OCD/documents/DPGW-1RevisedDPRenewal6-8-2017.pdf

U.S. Bureau of Land Management, Handbook H-1624-1 Planning for Fluid Mineral Resources, available at https://www.blm.gov/sites/blm.gov/files/uploads/Media_Library_BLM_Policy_Handbook_H_1624_1.pdf

U.S. Bureau of Land Management, 2003, Farmington Resource Management Plan with Record of Decision: Farmington Field Office, available at https://eplanning.blm.gov/epl-front-office/projects/lup/64524/96667/116772/FDO_-_FFO_-_2003_-_Farmington_RMP_and_ROD.pdf

U.S. Energy Information Administration, 2017, Annual Energy Outlook with projections to 2050, available at https://www.eia.gov/outlooks/aeo/

U.S. Energy Information Administration, 2017, Cushing, Oklahoma WTI Spot Price, available at https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=A

U.S. Energy Information Administration, 2017, Henry Hub Natural Gas Spot Price, available at https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm

U.S. Energy Information Administration, 2017, U.S. Natural Gas Wellhead Price, available at https://www.eia.gov/dnav/ng/hist/n9190us3a.htm

U.S. Environmental Protection Agency, 2016, Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States (Final Report): U.S. Environmental Protection Agency, EPA/600/R-16/236F, available at https://www.epa.gov/hfstudy

U.S. Geological Survey San Juan Basin Assessment Team, 2013, Total petroleum systems and geologic assessment of undiscovered oil and gas resources in the San Juan Basin Province, exclusive of Paleozoic rocks, New Mexico and Colorado: U.S. Geological Survey Digital Data Series 69–F, available at https://pubs.usgs.gov/dds/dds-069/dds-069-f/

U.S. Geological Survey, 2002, Data Downloads for the San Juan Basin Province (5022): U.S. Geological Survey, National Oil and Gas Assessment, available at https://energy.usgs.gov/OilGas/AssessmentsData/NationalOilGasAssessment/USBasinSummaries.aspx?theTab=dataTab&provcode=5022

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Farmington Mancos-Gallup RMPA: Reasonable Foreseeable Development (RFD) projections by alternative
May 2019 Alternatives

All development in Planning Area (including Federal, Indian, state, and fee minerals)
All projections run from 2018 through 2037

Well counts	**Baseline RFD**	**A**	**B**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D**	**No Action**
Total wells	3,200	2,619	2,622	3,085	3,082	3,079	3,076	3,068	3,073	3,101	3,093
Horizontal wells	2,300	1,881	1,855	2,216	2,215	2,215	2,213	2,210	2,212	2,225	2,220
Vertical wells	900	738	767	869	867	864	863	858	861	876	873
% reduction in wells (vs. baseline)	0.0%	18.2%	18.1%	3.6%	3.7%	3.8%	3.9%	4.1%	4.0%	3.1%	3.3%

Surface disturbance	**Baseline RFD**	**A**	**B**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D**	**No Action**
Surface disturbance at beginning of plan (ac.) (unchanged across alternatives)	56,500	56,500	56,500	56,500	56,500	56,500	56,600	56,500	56,500	56,500	56,500
Max surface disturbance (ac.)	75,000	72,900	72,900	74,600	74,600	74,600	74,600	74,600	74,600	74,700	74,700
Surface disturbance at end of plan (ac.)	43,000	42,100	42,100	42,700	42,700	42,700	42,700	42,700	42,700	42,800	42,800

Production (new & existing wells)	**Baseline RFD**	**A**	**B**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D**	**No Action**
Production - oil (bbl)	279,561,000	234,221,000	231,844,000	270,538,000	270,412,000	270,379,000	270,160,000	269,791,000	270,031,000	271,553,000	270,998,000
Production - gas (Mcf)	5,083,680,000	4,459,863,000	4,485,016,000	4,964,109,000	4,959,961,000	4,955,038,000	4,951,671,000	4,940,872,000	4,947,525,000	4,983,369,000	4,974,128,000
Production - water (bbl)	187,223,000	156,530,000	157,503,000	181,266,000	181,072,000	180,855,000	180,690,000	180,186,000	180,495,000	182,188,000	181,742,000

Water use for hydraulic fracturing (nitro frack)	**Baseline RFD**	**A**	**B**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D**	**No Action**
Water used for HF (gal)	2,503,500,000	2,047,770,000	2,026,325,000	2,412,395,000	2,411,025,000	2,410,500,000	2,408,285,000	2,404,350,000	2,406,915,000	2,422,800,000	2,417,175,000
Water used for HF (ac.-ft.)	7,683	6,284	6,219	7,403	7,399	7,398	7,391	7,379	7,387	7,435	7,418

UPDATED water use for fracking (nitro fracturing)	**Baseline RFD**	**A**	**B**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D**	**No Action**
Water used for HF (gal)	3,784,857,120	3,095,697,244	3,059,766,632	3,646,954,696	3,645,027,613	3,644,502,667	3,641,173,448	3,635,567,181	3,639,246,365	3,662,373,640	3,653,963,099
Water used for HF (ac.-ft.)	11,615	9,500	9,390	11,192	11,186	11,185	11,174	11,157	11,168	11,239	11,214

UPDATED water use for fracking (slickwater fracturing)	**Baseline RFD**	**A**	**B**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D**	**No Action**
Water used for HF (gal)	40,718,443,788	33,300,947,906	32,847,507,184	39,231,662,547	39,213,677,383	39,213,152,437	39,177,707,055	39,123,926,545	39,159,721,891	39,391,604,221	39,302,903,275
Water used for HF (ac.-ft.)	124,960	102,197	100,805	120,398	120,342	120,341	120,232	120,067	120,177	120,888	120,616

Farmington Mancos-Gallup RMPA: Reasonable Foreseeable Development (RFD) projections by alternative
May 2019 Alternatives

Federal development only
All projections run from 2018 through 2037

Well counts	**Baseline RFD**	**A**	**B**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D**	**No Action**
Total wells	1,980	1,399	1,402	1,865	1,862	1,859	1,856	1,848	1,853	1,881	1,873
Horizontal wells	1,580	1,161	1,135	1,496	1,495	1,495	1,493	1,490	1,492	1,505	1,500
Vertical wells	400	238	267	369	367	364	363	358	361	376	373
% reduction in wells (vs. baseline)	0.0%	29.3%	29.2%	5.8%	6.0%	6.1%	6.3%	6.7%	6.4%	5.0%	5.4%

Surface disturbance	Baseline RFD	A	B	C1	C2	C3	C4	C5	C6	D	No Action
Surface disturbance at beginning of plan (ac.) (unchanged across alternatives)	38,700	38,700	38,700	38,700	38,700	38,700	38,700	38,700	38,700	38,700	38,700
Max surface disturbance (ac.)	50,500	48,300	48,400	50,000	50,000	50,000	50,000	50,000	50,000	50,100	50,100
Surface disturbance at end of plan (ac.)	34,700	33,900	33,900	34,500	34,500	34,500	34,500	34,500	34,500	34,500	34,500

Production (new & existing wells)	Baseline RFD	A	B	C1	C2	C3	C4	C5	C6	D	No Action
Production - oil (bbl)	187,905,000	142,504,000	140,124,000	178,816,000	178,692,000	178,658,000	178,438,000	178,069,000	178,311,000	179,836,000	179,281,000
Production - gas (Mcf)	3,044,124,000	2,416,476,000	2,441,627,000	2,920,719,000	2,916,574,000	2,911,646,000	2,908,282,000	2,897,482,000	2,904,134,000	2,939,977,000	2,930,738,000
Production - water (bbl)	111,583,000	80,780,000	81,750,000	105,515,000	105,325,000	105,103,000	104,938,000	104,434,000	104,746,000	106,439,000	105,993,000

Water use for hydraulic fracturing	Baseline RFD	A	B	C1	C2	C3	C4	C5	C6	D	No Action
Water used for HF (gal)	1,681,600,000	1,225,870,000	1,204,425,000	1,590,495,000	1,589,125,000	1,588,600,000	1,586,385,000	1,582,450,000	1,585,015,000	1,600,900,000	1,595,275,000
Water used for HF (ac.-ft.)	5,161	3,762	3,696	4,881	4,877	4,875	4,868	4,856	4,864	4,913	4,896

UPDATED water use for fracking (nitro fracturing)	Baseline RFD	A	B	C1	C2	C3	C4	C5	C6	D	No Action
Water used for HF (gal)	2,561,840,562	1,872,680,686	1,836,750,074	2,423,938,138	2,422,011,055	2,421,486,109	2,418,156,889	2,412,550,623	2,416,229,807	2,439,357,081	2,430,946,541
Water used for HF (ac.-ft.)	7,862	5,747	5,637	7,439	7,433	7,431	7,421	7,404	7,415	7,486	7,460

UPDATED water use for fracking (slickwater fracturing)	Baseline RFD	A	B	C1	C2	C3	C4	C5	C6	D	No Action
Water used for HF (gal)	27,933,608,795	20,516,112,913	20,062,672,191	26,446,827,553	26,428,842,389	26,428,317,443	26,392,872,061	26,339,091,551	26,374,886,897	26,606,769,227	26,518,068,281
Water used for HF (ac.-ft.)	85,725	62,962	61,570	81,162	81,107	81,106	80,997	80,832	80,942	81,653	81,381

Farmington Mancos-Gallup RMPA: Reasonable Foreseeable Development (RFD) projections by alternative
September 2019 Additional Alternative (B2)

All development in Planning Area (including Federal, Indian, state, and fee minerals)
All projections run from 2018 through 2037

Well counts	B2
Total wells	2,345
Horizontal wells	1,595
Vertical wells	750
% reduction in wells (vs. baseline)	26.7%

Surface disturbance	B2
Surface disturbance at beginning of plan (ac.) (unchanged across alternatives)	56,500
Max surface disturbance (ac.)	72,000
Surface disturbance at end of plan (ac.)	41,800

Production (new & existing wells)	B2
Production - oil (bbl)	204,614,000
Production - gas (Mcf)	4,232,640,000
Production - water (bbl)	144,554,000

Water use for hydraulic fracturing	B2
Water used for HF (gal)	1,758,150,000
Water used for HF (ac.-ft.)	5,396

UPDATED water use for fracking (nitro f	B2
Water used for HF (gal)	2,646,741,040
Water used for HF (ac.-ft.)	8,123

UPDATED water use for fracking (slickw	B2
Water used for HF (gal)	28,259,380,490
Water used for HF (ac.-ft.)	86,725

Farmington Mancos-Gallup RMPA: Reasonable Foreseeable Development (RFD) projections by alternative

September 2019 Additional Alternative (B2)

Federal development only

All projections run from 2018 through 2037

Well counts	**B2**
Total wells	1,125
Horizontal wells	875
Vertical wells	250
% reduction in wells (vs. baseline)	43.2%

Surface disturbance	**B2**
Surface disturbance at beginning of plan (ac.) (unchanged across alternatives)	38,700
Max surface disturbance (ac.)	47,400
Surface disturbance at end of plan (ac.)	33,600

Production (new & existing wells)	**B2**
Production - oil (bbl)	112,895,000
Production - gas (Mcf)	2,189,249,000
Production - water (bbl)	68,804,000

Water use for hydraulic fracturing	**B2**
Water used for HF (gal)	936,250,000
Water used for HF (ac.-ft.)	2,873

UPDATED water use for fracking (nitro f	**B2**
Water used for HF (gal)	1,423,724,482
Water used for HF (ac.-ft.)	4,369

UPDATED water use for fracking (slickw	**B2**
Water used for HF (gal)	15,474,545,497
Water used for HF (ac.-ft.)	47,490

2019 Farmington Field Office Slick Water Stimulation Use Update

Purpose of the Update

Fluid mineral development in the San Juan Basin has experienced technological advances with the introduction of slick water stimulation beginning in 2015. Since the development of the Reasonable Foreseeable Development Scenario for Oil and Gas Activities, Mancos-Gallup RMPA Planning Area (Crocker and Glover, 2018)[1] and the 2019 BLM New Mexico Water Support Document (WSD) (BLM, 2019)[2], additional information regarding the slick water stimulation technique has been gathered by the Bureau of Land Management Farmington Field Office, (BLM-FFO). To fully understand this update, see Crocker and Glover (2018)[1], pages 2-7 and 2019 WSD by BLM (2019)[2], pages 20-36. The purpose of this update is to address the forecasted amount of water from the 2018 Mancos-Gallup RFD, which may be used during development of the Mancos Shale formation and Gallup Sandstone member utilizing slick water stimulation in the San Juan Basin.

Assumptions and Methodology

This update evaluates the potential water requirements for the development of the Mancos Shale and Gallup Sandstone within the San Juan Basin using the slick-water stimulation technique. Current industry trends in unconventional reservoir development have shifted to drilling of long (1-3 mile) horizontal laterals that are stimulated using large volumes of low-viscosity water-based fluids (slick-water stimulation). This development scenario evaluates the projected water demand of Mancos-Gallup development based on current industry expectations of lateral density. No evaluation of other factors (i.e. execution pace, reservoir recovery factor, economic results, alternative completion techniques) are made in this model.

The 2018 Mancos-Gallup RFD presents the projected fluid mineral development potential for the Mancos-Gallup RMPA Planning Area, encompassing a total area of 4 million acres. Half of the total planning area (2 million acres) is located within one major horizontal oil and gas play, resulting in fluid mineral interest with" high" and "medium" development potential[1].

Horizontal wells are currently stimulated during completion in short sections of laterals called stages. To date, 20 wells have been drilled using long laterals with slick-water stimulation within the Farmington Field Office (BLM-FFO). The water volume and stage length was averaged from the 20 wells using the APD and data from FracFocus. The equation for calculating estimated water volume is indicated below:

(Total water volume) = (stage water volume/stage length) x (number of stages/lateral length)

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[1] https://eplanning.blm.gov/epl-front-office/projects/nepa/110578/161453/197157/2018.02.27_Crocker_Glover_FFO_RFD.pdf

[2] https://www.blm.gov/sites/blm.gov/files/2019%20BLM%20NM%20Water%20Support%20Document_07122019_508.pdf

The total miles of lateral estimated to develop the Mancos Shale and Gallup Sandstone formations is based on the 2300 horizontal wells projected in the 2018 RFD. On average the wells would be stimulated in 2 mile laterals which would be approximately 4,600 miles, all of which are projected to be slick-water stimulated. For the 20 completed wells the FFO calculated the average stage length to be 200 feet and the average water used per stage to stimulate the formation to be 334,000 gallons (~ 1 acre-foot). From the BLM-FFO projected water use calculations, the Mancos Shale and Gallup Sandstone development within the high and medium potential areas would require approximately 125,000 acre-feet for the full development scenario using only slick-water stimulation techniques (see Table 1).

Context

The Colorado River Compact (The Compact) of 1922 determined how much water would be delivered downstream for use in the western states listed in The Compact. The remaining water is left to the individual states for allocation. It is the responsibility of the New Mexico Office of the State Engineer (NMOSE) to allocate remaining useable water within New Mexico and to ensure that all water is used according to state regulations and correctly reported. The authority and regulation of the NMOSE applies to water acquired for use in production and operation of oil and natural gas wells. Water use is published in a report every five years in the report titled "New Mexico Water Use By Categories", most recently published in 2015. The WSD (BLM 2019)[2] discusses the volume of water that was used specifically for hydraulic stimulation of oil and gas wells using information from the NMOSE 2015 report. Chapter 3 of the WSD discusses the volume of water utilized to stimulate the oil and gas wells within the Farmington Field Office.

The two general water types that may be used for slick water stimulation are categorized as "potable/fresh" and "non-potable". Any water that has Total Dissolved Solids (TDS) greater than 1,000 ppm has been defined as "non-potable" by the State of New Mexico (72-12-25 NMSA 1978)[3], the BLM has identified anything less than 10,000 ppm to be protected in the casing rule of the BLM's Onshore Order #2[4]. Non-potable water is outside the appropriative processes and is mainly diverted for mineral exploration purpose. Conversely, any water that is less than 1,000 ppm TDS is "potable/fresh". In general potable water has a water right associated with it and is permitted and regulated by the NMOSE and may or may not be adjudicated.

During the process of gathering information regarding slick-water stimulation, the BLM-FFO put together a questionnaire to conduct industry interviews. The questionnaire focused on estimated water use during drilling, completion, operation and production phases of oil and gas wells, with specific focus on water sources and water use associated with slick water stimulation. The questions were used to help the BLM determine how saline water is being utilized and to better

[3] https://laws.nmonesource.com/w/nmos/Chapter-72-NMSA-1978#!fragment/zoupio-_Toc14959739/BQCwhgziBcwMYgK4DsDWszIQewE4BUBTADwBdoAvbRABwEtsBaAfX2zgEYAWATgFYeAdgDMPAJQAaZNlKEIARUSFcAT2gBydRIhxc2ADb6AwkjTQAhMm2EwuBIuVrN12wgDKeUgCE1AJQCiADL+AGoAggByRv4SpGAARtCk7GJiQA

[4] https://www.blm.gov/sites/blm.gov/files/energy_onshoreorder2.pdf

understand the potential TDS levels within source water for the stimulation fluid. Onshore Order #1[5] requires operators to identify adequate water sources for stimulation plans as part of their APD.

Based on operator input the water used for slick-water stimulation can have high levels of TDS for the technology to be effective. The majority of operators within the San Juan Basin limit their TDS levels to 50,000 ppm for use in a slick water stimulation operation. The higher allowable TDS levels that are acceptable for slick water stimulation expand the possible water sources beyond those that are traditionally used (e.g., surface or ground water) into non-traditional sources of water (e.g. non-potable groundwater sources).

Recently, the NMOSE has received Notices of Intention (NOI) to Appropriate non-potable water from aquifers at depths 2,500 feet below ground level (BGL) or greater. The NMOSE has approved permits to drill wells within the San Juan Basin to withdraw non-potable connate water (groundwater) from the Entrada sandstone formation for use as a potential source of water for slick water stimulation operations. Modeling conducted by NMOSE reflected impacts to the adjacent surface system therefore requiring the applicants to obtain water rights on those systems to offset the depletions prior to commencing diversions. The depleted offset water rights associated with the NOI are purchased by the individual or group applying for the NOI and subsequent permit to drill a well. The Entrada sandstone formation maximum depth is approximately 9,500 feet deep. Water contained in the Entrada formation typically measures much greater than 1,000 TDS, is highly saline water (Kelley et al, 2014)[6], and has not been declared as administrative aquifers by the NMOSE.

Other sources of non-potable water that can be utilized in stimulation are “flowback fluid” and “produced water”. Flowback fluid is a mixture of chemical proppant, water and sand that flows back through the well head directly after stimulation activities. Generally, 10-40% of the initial volume utilized for stimulation activities returns as flowback fluid, of this 10-40% is non-potable water that may be used in future stimulation activities. Produced water is naturally occurring water that exists in the formation that is being targeted for mineral extraction and is produced a byproduct, therefore becoming “produced water”. Based on operator input, after the initial flowback recovery of 10-40%, remaining water used for stimulation does return to the surface through production activities at a slower rate of return.

Projected Water Use Discussion

To gain the most current information, outreach was conducted with local operators actively drilling and producing mineral resources in the San Juan Basin to gather information regarding slick-water stimulation and reservoir development. According to the 20 APDs the average lateral well bore is one and a half miles (1.5) in length for a horizontal well. The estimated water use is approximately 41 acre feet (af) for slick water stimulation. Advances in horizontal drilling and completion techniques in the San Juan Basin in the past four to five (4-5) years has resulted in

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[5] https://www.blm.gov/sites/blm.gov/files/Order_1_2007.pdf

[6] https://geoinfo.nmt.edu/publications/openfile/downloads/500-599/566/ofr-566.pdf

the ability to drill and complete horizontal laterals up to three (3) miles in length (according to operator input). Horizontal well bores are stimulated in intervals, each interval is called a stage. Refer to table 1 for number of stages dependent on length of well bore as well as the average water use of 1-3 mile laterals per completion.

Table 1: Average volume of water required to complete 1-3 mile laterals utilizing slick water stimulation in the Mancos Shale and Gallup Sandstone formations.

Miles	Number of Stages	Acre Feet
1	26	27
1.5	39	40
2	52	53
2.5	65	67
3	78	80

Conclusions

The amount of water that would be required to completely develop 4,600 miles of horizontal wells in the Mancos Shale and Gallup Sandstone formations via slick-water stimulation has been estimated to be approximately 125,000 af. The 2018 RFD estimates 2,300 horizontal wells that may be developed in 2018-2037, based on operator input the horizontal lengths will range from 1-3 miles. Current technology allows operators to utilize water with TDS of 50,000 ppm, well above the NMOSE potable water threshold of 1,000 ppm. This allows for the use of currently non-traditional potable water sources, including the connate water within the Entrada formation and recycled flowback water and produced water for use in slick water stimulation activities.

U.S. Department of the Interior
Bureau of Land Management

2019 BLM New Mexico Water Support Document

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Bureau of Land Management:
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Santa Fe, New Mexico 87508
505-954-2000

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LIST OF ACRONYMS AND ABBREVIATIONS

AF	Acre-feet
Ag	Silver
Al	Aluminum
APD	Application for Permit to Drill
As	Arsenic
Ba	Barium
Bbls	Barrels
BLM	Bureau of Land Management
Br	Bromide
BS&W	Basic sediment and water
Ca2	Calcium
CaCO3	Alkalinity
Cd	Cadmium
Cl	Chloride
COA	Conditions of approval
CO3-	Carbonate
CFR	Code of Federal Regulations
Cu	Copper
CWA	Clean Water Act
EIS	Environmental Impact Statement
F	Fluoride
Fe	Iron
FO	Field Office
gpm	gallons per minute
HCO3	Bicarbonate
HPA	high potential areas
K+	Potassium
L	Liter
Li	Lithium
MCF	thousand cubic feet
mg	milligrams
mg/L	milligrams per Liter
Mg2	Magnesium
Mn	Manganese
Na+	Sodium
NEPA	National Environmental Policy Act
Ni	Nickel

NMAC	New Mexico Administrative Code
NMOCD	State of New Mexico Oil Conservation Division
NMOSE	State of New Mexico Office of the State Engineer
NMWQCC	New Mexico Water Quality Control Commission
NO2	Nitrite
NO3	Nitrate
Pb	Lead
psi	Pounds per square inch
RFFA	Reasonably Foreseeable Future Actions
RMP	Resource Management Plan
RFD	Reasonable Foreseeable Development
Si	Silicon
SO42	Sulfate
Sr2	Strontium
TDS	total dissolved solids
TDS	Total Dissolved Solids
TMDLs	total maximum daily loads
U.S.	United States
USGS	U.S. Geological Survey
V	Vanadium
WIPP	Waste Isolation Pilot Plant
µmhos/cm	Specific Conductance

CHAPTER 1. INTRODUCTION

1.1. Purpose of the Report

The intent of this document is to collect and present the data and information needed for water resources analysis to be incorporated by reference into National Environmental Policy Act (NEPA) documents, most specifically the proposed NEPA analysis related to federal oil and gas development under the jurisdiction of the Bureau of Land Management (BLM) New Mexico State Office. This includes federal mineral rights within the Pecos District, Farmington Field Office (FO), and Rio Puerco FO.

1.2. Report Organization

Chapter 2 summarizes water quantity and quality data for the Pecos District, which comprises the Carlsbad and Roswell FOs and the Hobbs Field Station. Chapters 3and 4 summarize water quantity and quality data for the Farmington FO and the Rio Puerco FO, respectively. Chapter 5 summarizes how to use this report to inform analyses of water use at the site-specific level. Each chapter contains the references that are pertinent to the analysis.

1.3. Updating of the Report

The BLM will update this report with new data as it becomes available. FracFocus data on actual water use is released annually. As this data is released the BLM will review it to consider if the cumulative analysis of water use requires updating. The State of New Mexico Office of the State Engineer (NMOSE) and U.S. Geological Survey (USGS) data, “Water Use by Category,” is updated every five years. The reporting on the spills data will be updated annually (Appendix B).

CHAPTER 2. PECOS DISTRICT

The BLM Pecos District Office, which oversees the Carlsbad and Roswell FOs and the Hobbs Field Station, encompasses over 3.5 million acres of public lands and over 7 million acres of federal mineral estate. The Pecos District includes the New Mexico portion of the Permian Basin, a sedimentary depositional basin. The Permian Basin is one of the premier oil and gas producing regions in the United States (U.S.), and prolific producing horizons occur in the New Mexico portion of the basin in Eddy and Lea Counties. The Permian Basin has been a producing oil and natural gas field since the early 1900s. According to available GIS data and the Petroleum Recovery Research Center, approximately 17,735 active federal wells are within the boundaries of the Pecos District.

This chapter presents information on existing and projected water quantity and water quality data for the Pecos District as summarized from information gathered from the following sources: 1) the Reasonable Foreseeable Development (RFD) Scenario for the BLM New Mexico Pecos District (Engler and Cather 2012; 2014), 2) data compiled from a 2015 USGS report, Estimated Use of Water in the United States in 2015 (Dieter et al. 2018), and 3) FracFocus, a national hydraulic fracturing chemical registry managed by the Ground Water Protection Council and Interstate Oil and Gas Compact Commission (FracFocus 2018).

2.1. Water Quantity

2.1.1. Existing Surface and Groundwater Water Use

Pecos District

The 2015 USGS Report, Estimated Use of Water in the United States in 2015 (Dieter et al. 2018), lists total water withdrawals across eight water use categories: aquaculture, domestic, industrial, irrigation, livestock, mining, public water supply, and thermoelectric power. Table 2-1 through Table 2-3 list the total 2015 water withdrawals for the eight water use categories for each of the three counties within the Pecos District ("Pecos District Tri-County Area"). Table 2-4 presents combined water use for the Pecos District Tri-County Area. This area is roughly analogous to the New Mexico portion of the Permian Basin. As shown in the tables, *Irrigation* is the largest category of water use in all counties, accounting for an average of 75 percent (466,784 acre-feet ([AF]) of the total water withdrawal for the Pecos District Tri-County Area (620, 416 AF). Approximately 88 percent (546,195 AF) of the total water use for the Pecos District Tri-County Area is from groundwater. *Mining* (which includes oil and gas development) comprises approximately 15 percent of Pecos District Tri-County Area water withdrawals. All mining-related water use (95,800 AF) is from groundwater. Of that total, 99 percent of withdrawals are from saline sources. Most (87 percent) of mining-related water use occurs in Lea County, where mining comprises 31 percent of the total county withdrawals. The relative use of water by industry within the Pecos District Tri-County Area is depicted in Figure 2.1. The relative use of surface water and fresh/saline groundwater by industry within the Pecos District Tri-County Area is depicted in Figure 2.2.

Table 2-1. Lea County 2015 Water Use by Category (AF)

Category	Surface Water				Groundwater				Total Withdrawals					
	AF Fresh	Saline	Total	% of Total Use	Fresh	Saline	Total Ground water	% of Total Use	Fresh	% of Total Use	Saline	% of Total Use	Total	% of Total Use
Public Water Supply	0	0	0	0%	11,423	0	11,423	100%	11,423	100%	0	0%	11,423	4%
Industrial	0	0	0	0%	78	0	78	100%	78	100%	0	0%	78	0%
Irrigation	0	0	0	0%	166,099	0	166,099	100%	166,099	100%	0	0%	166,099	62%
Livestock	56	0	56	2%	2,870	0	2,870	98%	2,926	100%	0	0%	2,926	1%
Aquaculture	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Mining	0	0	0	0%	325	81,642	81,968	100%	325	0.4%	81,642	99.6%	81,968	31%
Thermoelectric Power	0	0	0	0%	1,827	0	1,827	100%	1,827	100%	0	0%	1,827	1%
Domestic	0	0	0	0%	1,513	0	1,513	100%	1,513	100%	0	0%	1,513	1%
County Totals	**56**	**0**	**56**	**0%**	**184,136**	**81,642**	**265,778**	**100%**	**184,192**	**69%**	**81,642**	**31%**	**265,834**	**100%**

Source: Dieter et al. 2018.
Note: AF is acre-feet

Table 2-2. Eddy County 2015 Water Use by Category (AF)

Category	Surface Water				Groundwater				Total Withdrawals					
	AF Fresh	AF Saline	AF Total	% of Total Use	AF Fresh	AF Saline	AF Total	% of Total Use	AF Fresh	% of Total Use	AF Saline	% of Total Use	AF Total	% of Total Use
Public Water Supply	0	0	0	0%	15,077	0	15,077	100%	15,077	100%	0	0	15,077	8%
Industrial	0	0	0	0%	1,043	0	1,043	100%	1,043	100%	0	0%	1,043	1%
Irrigation	64,054	0	64,054	42%	89,994	0	89,994	58%	154,048	100%	0	0%	154,048	84%
Livestock	34	0	34	3%	1,289	0	1,289	97%	1,323	100%	0	0%	1,323	1%
Aquaculture	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Mining	0	0	0	0%	1,169	10,993	12,162	100%	1,169	10%	10,993	90%	12,162	6%
Thermoelectric Power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Domestic	0	0	0	0%	258	0	258	100%	258	100%	0	0%	258	0%
County Totals	**64,088**	**0**	**64,088**	**35%**	**108, 830**	**10,993**	**119,823**	**65%**	**172,918**	**94%**	**10,993**	**6%**	**183,910**	**100%**

Source: Dieter et al. 2018. Note: AF is acre-feet

Table 2-3. Chavez County 2015 Water Use by Category (AF)

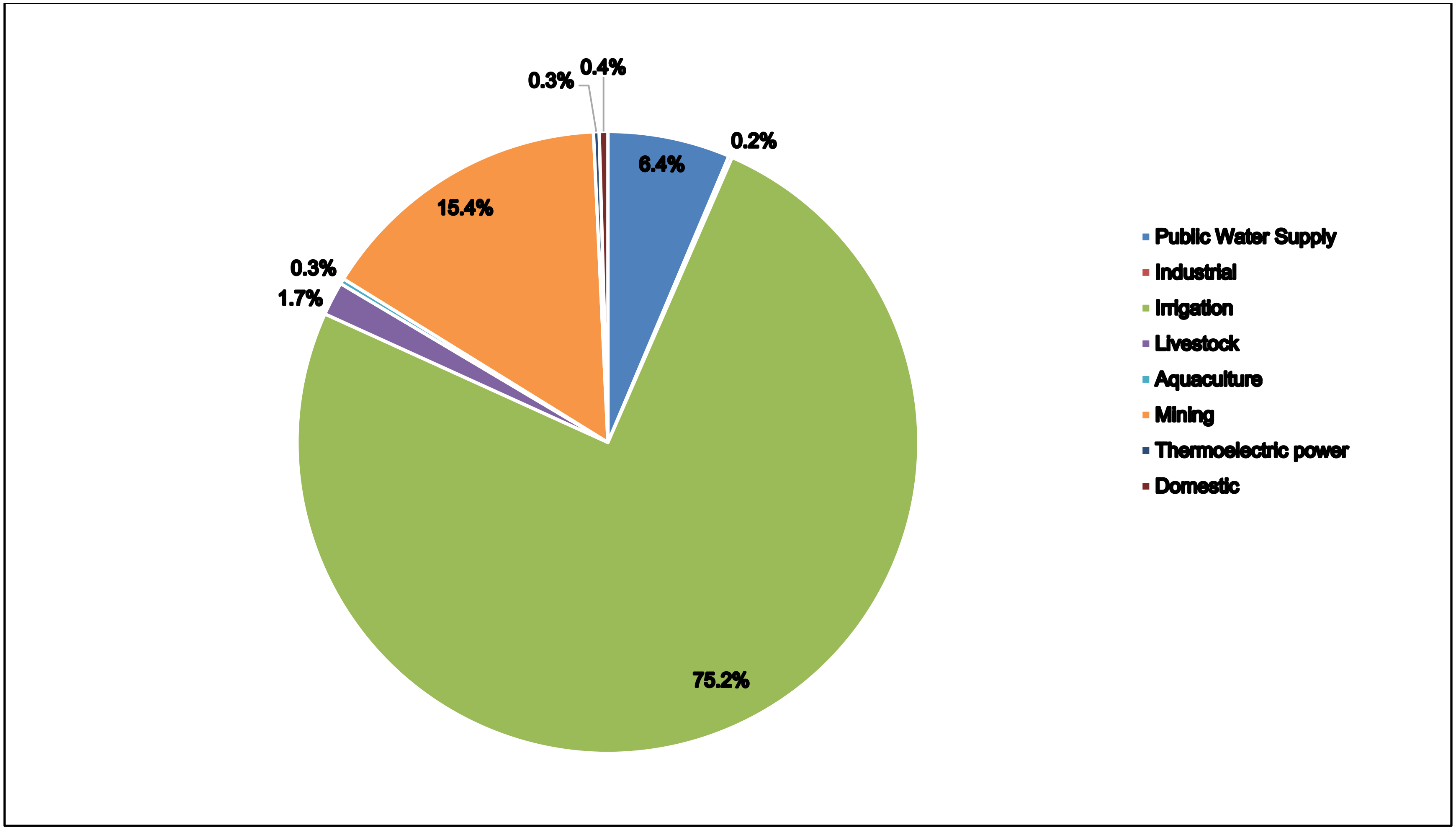
Category	Surface Water				Groundwater				Total Withdrawals					
	AF Fresh	AF Saline	AF Total	% of Total Use	AF Fresh	AF Saline	AF Total	% of Total Use	AF Fresh	% of Total Use	AF Saline	% of Total Use	AF Total	% of Total Use
Public Water Supply	0	0	0	0%	12970	0	12,970	100%	12,970	100%	0	0	12,970	8%
Industrial	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Irrigation	9,854	0	9,854	7%	136,784	0	136,784	93%	146,638	100%	0	0%	146,638	86%
Livestock	224	0	224	3%	6,378	0	6,378	97%	6,603	100%	0	0%	6,603	4%
Aquaculture	0	0	0	0%	1,782	0	1,782	100%	1,782	100%	0	0%	1,782	1%
Mining	0	0	0	0%	78	1,592	1,670	100%	78	5%	1,592	95%	1,670	1%
Thermoelectric Power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Domestic	0	0	0	0%	1,009	0	1,009	100%	1,009	100%	0	0%	1,009	1%
County Totals	**10,078**	**0**	**10,078**	**6%**	**159,003**	**1,592**	**160,594**	**94%**	**169,080**	**99%**	**1,592**	**1%**	**170,672**	**100%**

Source: Dieter et al. 2018.

Table 2-4. Pecos District Tri-County Area 2015 Water Use by Category (AF)

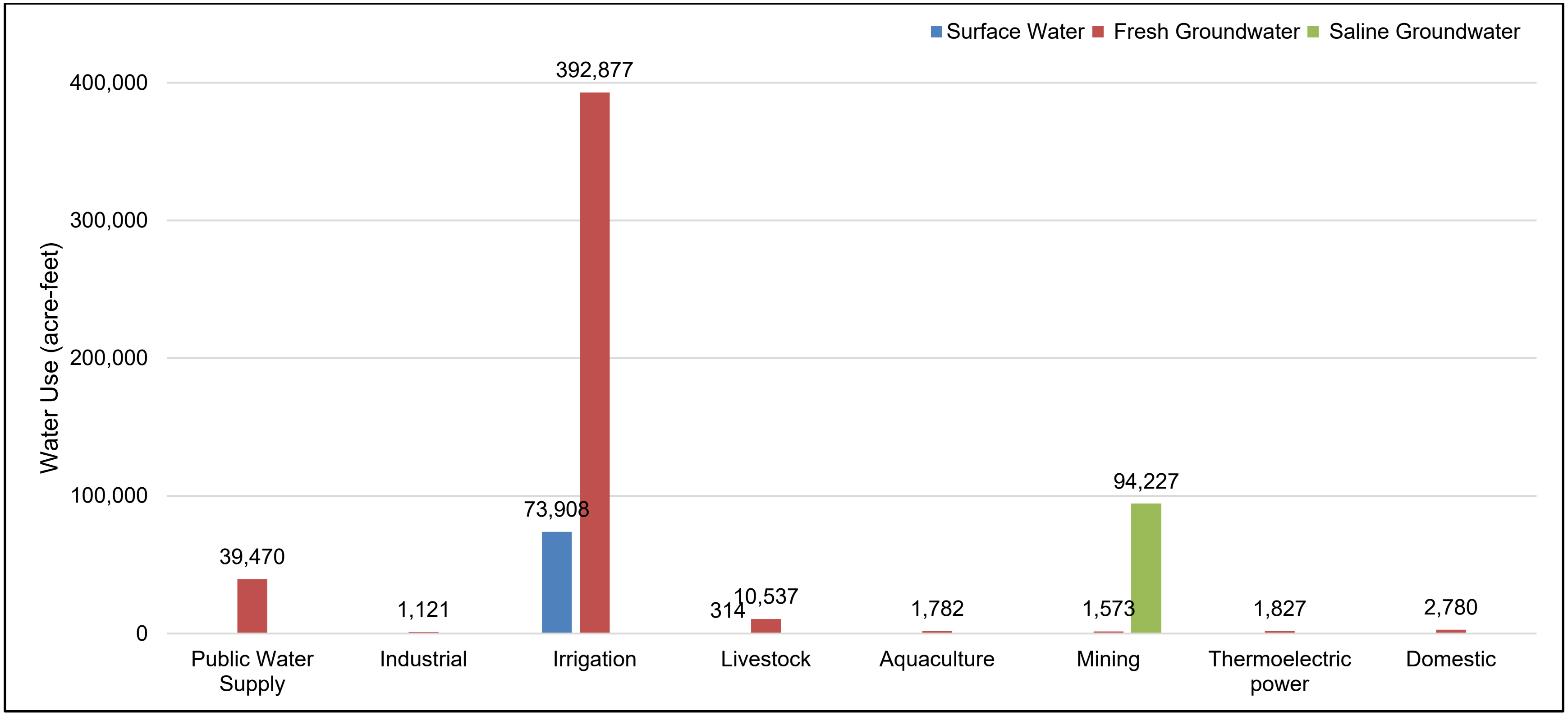
Category	Surface Water				Groundwater				Total Withdrawals					
	AF Fresh	AF Saline	AF Total	% of Total Use	AF Fresh	AF Saline	AF Total	% of Total Use	AF Fresh	% of Total Use	AF Saline	% of Total Use	AF Total	% of Total Use
Public Water Supply	-	-	-	0%	39,470	-	39,470	100%	39,470	100%	0	0	39,470	6%
Industrial	-	-	-	0%	1,121	-	1,121	100%	1,121	100%	0	0%	1,121	0%
Irrigation	73,908	-	73,908	16%	392,877	-	392,877	84%	466,784	100%	0	0%	466,784	75%
Livestock	314	-	314	3%	10,537	-	10,537	97%	10,851	100%	0	0%	10,851	2%
Aquaculture	-	-	-	0%	1,782	-	1,782	100%	1,782	100%	0	0%	1,782	0%
Mining	-	-	-	0%	1,573	94,227	95,800	100%	1,573	1%	24,227	99%	95,800	15%
Thermoelectric Power	-	-	-	0%	1,827	-	1,827	100%	1,827	100%	0	0%	1,827	0%
Domestic	-	-	-	0%	2,780	-	2,780	100%	2,780	100%	0	0%	2,780	0%
District Totals	**74,221**	**-**	**74,221**	**12%**	**451,968**	**24,227**	**546,195**	**88%**	**526,195**	**85%**	**24,227**	**15%**	**620,416**	**100%**

Source: Dieter et al. 2018. Note: AF is acre-feet.



Source: Dieter et al. 2018.

Figure 2.1. Pecos District Tri-County Area 2015 water use (in acre-feet) by category.



Source: Dieter et al. 2018.

Figure 2.2. Pecos District Tri-County Area 2015 water use (acre-feet) by water type and category.

State of New Mexico Water Use

In 2015, withdrawals for all water use categories across the State of New Mexico totaled 3,249,667 AF (Dieter et al. 2018). Pecos District Tri-County Area total water usage (620,416 AF) accounted for about 19 percent of the total state withdrawals. Table 2-5 lists the water for the major categories in New Mexico. As shown in the table, *Mining* water withdrawals totaled 163,901 AF, or about 5 percent of the total water withdrawals for the State of New Mexico. While the data presented in this table are for the state as a whole, most water use in this category is from the Permian Basin with some water use from the San Juan Basin. Table 2-6 presents water use associated with oil and gas development in New Mexico, by county. As shown in Table 2-6, over 99 percent of the water use associated with oil and gas development occurs in the Pecos District Tri-County Area (3,994 AF). Water use associated with oil and gas development comprises approximately 2.5 percent of the statewide *Mining* water use (163,901 AF, see Table 2-5) and 4.2 percent of the Pecos District Tri-County Area *Mining* water use (95,800 AF, see Table 2-4.

Table 2-5. State of New Mexico 2015 Use by Category (AF)

Category	Surface Water				Groundwater				Total Withdrawals					
	AF Fresh	AF Saline	AF Total	% of Total Use	AF Fresh	AF Saline	AF Total	% of Total Use	AF Fresh	% of Total Use	AF Saline	% of Total Use	AF Total	% of Total Use
Public Water Supply	87,752	-	87,752	30%	205,715	-	205,715	70%	293,467	100%	-	-	293,467	9%
Industrial	-	-	-	0%	3,811	-	3,811	100%	3,811	100%	-	-	3,811	0%
Irrigation	1,485,112	-	1,485,112	56%	1,175,312	-	1,175,312	44%	2,660,424	100%	-	-	2,660,424	82%
Livestock	2,522	-	2,522	7%	33,372	-	33,372	93%	35,894	100%	-	-	35,894	1%
Aquaculture	6,109	-	6,109	23%	20,929	-	20,929	77%	27,039	100%	-	-	27,039	1%
Mining†	19,550	-	19,550	12%	44,111	100,240	144,351	88%	63,662	39%	100,240	61%	163,901	5%
Thermoelectric Power	30,637	-	30,637	82%	6,872	-	6,872	18%	37,509	100%	-	-	37,509	1%
Domestic	-	-	-	0%	27,621	-	27,621	100%	27,621	100%	-	-	27,621	1%
Totals	1,631,683	-	1,631,683	50%	1,517,744	100,240	1,617,984	50%	3,149,427	97%	100,240	3%	3,249,667	100%

Source: Dieter et al. 2018; updated with additional information provided to the BLM from the New Mexico Office of the State Engineer (NMOSE) regarding water use of the Navajo Power Plant (BLM 2019a).

† Approximately 19,550 AF of the freshwater use within the Mining industry is from surface water; the remainder of all other water use is from groundwater. The Mining category includes the following self-supplied enterprises that extract minerals occurring naturally in the earth's crust: solids, such as potash, coal, and smelting ores; liquids, such as crude petroleum; and gases, such as natural gas. This category includes water used for oil and gas production (well drilling and secondary recovery of oil), quarrying, milling (crushing, screening, washing, flotation, etc.), and other processing done at the mine site or as part of a mining activity, as well as water removed from underground excavations (mine dewatering) and stored in—and evaporated from—tailings ponds. The Mining category also includes water used to irrigate new vegetative covers at former mine sites that have been reclaimed. It does not include the processing of raw materials, such as smelting ores, unless this activity occurs as an integral part of a mining operation and is included in an NMOSE permit.

Note: AF is acre-feet.

Table 2-6. 2015 State of New Mexico Water Use Associated with Oil and Gas Development (AF)

County	Surface Water	Groundwater	Total	% of Total
Bernalillo	0	7	7	0%
Chaves	0	84	84	2%
Eddy	0	2,635	2,635	65%
Lea	0	1,275	1,275	32%
San Juan	30	0	30	1%
Sierra	0	1	1	0%
State Total	**30**	**4,002**	**4,032**	**100%**

Source: NMOSE 2019.
Note: AF is acre-feet.

2.1.2. Water Use Associated with Reasonably Foreseeable Oil and Gas Development

The reasonable foreseeable development (RFD) scenario for the BLM New Mexico Pecos District (Engler and Cather 2012; 2014) was developed as a reasonable estimate of development associated with hydrocarbon production in southeast New Mexico for the next 20 years in the New Mexico portion of the Permian Basin. The RFD is a comprehensive study of all existing plays and an analysis of recent activity, historical production, emerging plays for future potential, and completion trends. Table 2-7 presents planning factors from the RFD.

Table 2-7. RFD Planning Factors

Factor	RFD
Time Frame	2015–2035
Number of wells	16,000 (approximately 800 per year, federal and non-federal)
Average Water Use, Horizontal Well	7.3 AF (2.4 million gallons)+
Average Water Use, Vertical Well	1.53 AF (500,000 gal)
Number of Wells Needed for Reservoir Development (play)	4 wells per section per play (horizontal wells)
Percentage of horizontal wells in Bone Spring Formation	84% horizontal
Percentage of horizontal wells in Leonard Formation	14% horizontal

Source: Engler and Cather 2012; 2014
+ Although the RFD (Engler and Cather 2012; Engler and Cather 2014) estimates water use for a single horizontal well to be 7.3 AF, additional information (FracFocus 2018; Kondash et al. 2018) has shown that water use in the Permian Basin has increased based on an increased use of hydraulic fracturing.
Note: AF is acre-feet.

As shown in the table above, the RFD concluded that the average water use for a single horizontal well was 7.3 AF. This figure was based on a study of the Bone Spring Formation using data from 2013. Since that time, an estimate of 34.4 AF/horizontal well for the Permian Basin in 2016 was provided by Kondash et al. (2018). The report concluded that "…the Permian Basin (Texas and New Mexico) had the largest increase in water use (770 percent), from 4900 m^3 per well (3.97 AF) in 2011 to 42500 m^3 per well (34.4 AF) in 2016" (Kondash et al. 2018). Because of this new information, BLM conducted studies using calendar year 2017 and 2018 data from FracFocus, a national hydraulic fracturing chemical registry managed by the Ground Water Protection Council and Interstate Oil and Gas Compact Commission, to provide objective information on hydraulic fracturing. Operators are required by the State of New Mexico to disclose chemistry and water use information on FracFocus.

Reported water use in 2017 was 13,962 AF, of which 21 percent (2,959 AF) was associated with federal wells (FracFocus 2017). Reported water use in 2018 was 21,742 AF, of which 32 percent (6,936 AF) was associated with federal wells (FracFocus 2018). These figures are higher than 2015 reported oil and gas water use (see Table 2-6) and corroborate that water use associated with hydraulic fracturing in the Permian Basin has been increasing in recent years. Analysis of the 2017 data set, consisting of 522 records, resulted in an expected value of 26.9 AF, standard deviation of 17.47 AF, and a median of 24.78 AF. Analysis of the 2018 data set, consisting of 696 records, resulted in a mean of 31.2, standard deviation of 18.8 AF, and a median of 27.98 AF. As a result of these studies, the BLM considers the estimate of 31.2 AF as the best current estimate of water use per horizontal well in the Pecos District.

Note that if more water-intensive stimulation methods (e.g., slick water fracturing) are implemented or if laterals become longer, water use could increase from this estimate. Alternatively, water use estimates could be lower if produced water is reused or recycled for use in hydraulic fracturing. Public concern about water use from hydraulic fracturing is especially high in semiarid regions, where water withdrawals for hydraulic fracturing can account for a significant portion of consumptive water use within a given region. The BLM will continue to evaluate reported water use in FracFocus and other data and will revise water use estimates to be used in NEPA evaluations accordingly.

2.1.3. Cumulative Water Use Estimates

Past and Present Actions

Pecos District total water usage (620,416 AF) accounted for about 19 percent of the total state withdrawals (3,249,667 AF). Mining (which includes oil and gas development) comprises approximately 15 percent of Pecos District water withdrawals. Water use associated with oil and gas development (4,032 AF) comprises approximately 2.5 percent of the statewide Mining water use (163,901 AF), 4.3 percent of the Pecos District Tri-County Area Mining water use (95,800 AF), and 0.7 percent of Pecos District total water usage. The largest water use category within the county and the state is agricultural, comprising 75 percent of all water use within the Pecos District and 82 percent of all water use within the state. This trend is expected to continue.

The BLM examined FracFocus data reported for the calendar years of 2014 to 2018 (FracFocus 2019) to ascertain water use, cumulative water use, and water use trends in the New Mexico portion of the Permian Basin; that is, for Chaves, Eddy, and Lea Counties (Table 2-8).

Consumptive water use by municipal, industrial, and agricultural activities (including oil and gas activities) represents a single element of a hypothetical water budget for the planning area. While a detailed water budget quantifying hydrologic inputs and outputs for the planning area is outside the scope of this document, it should be noted that various hydrologic inputs are occurring alongside the consumptive water use depicted in Figure 2.4 and Figure 2.5. Groundwater can be recharged through a variety of processes such as precipitation, irrigation return flow, and seepage from rivers and streams. Similarly, groundwater discharge in the planning area occurs not only through consumptive water use, but also through evapotranspiration and discharge from springs and seeps.

Table 2-8. Actual Water Use in the New Mexico Portion of the Permian Basin for Calendar Years 2014-2018

Year	Federal Water Use (AF)	Non-Federal Water Use (AF)	Total Water Use (AF)	Federal Water Use (Percent)	Federal Cumulative Water Use (AF)	Total Cumulative Water Use (AF)	Average Water Use per Well (AF)	Total # of Wells Reported to FracFocus
2014	1,307	2,509	3,816	34%	1,307	3,816	6.82	559
2015	4,033	4,336	8,369	48%	5,340	12,185	15.82	529
2016	710	6,091	6,801	10%	6,050	18,986	21.66	314
2017	2,964	11,418	14,382	21%	9,014	33,368	26.44	544
2018	8,411	19,681	28,092	30%	17,425	61,460	31.04	905
Total	**17,425**	**44,035**	**61,460**	**--**	**--**	**--**	**--**	**2,851**

Source: FracFocus 2019
Note: The New Mexico portion of the Permian Basin is comprised of Lea, Chaves, and Eddy Counties.

Water use has increased from 3,816 AF in 2014 to 28,092 AF in 2018, with a corresponding basin-wide average water use per well increase from 6.82 AF per well to 31 AF per well (FracFocus, 2019). A cumulative total of 61,460 AF of water was used for oil and gas between the years 2014–2018 (FracFocus 2019). Total federal cumulative water use in the basin for the same time period was 17,425 AF, accounting for 28 percent of the total water use. The total number of wells that were reported to FracFocus increased from 559 wells in 2014 to 905 wells in 2018 (FracFocus 2019).

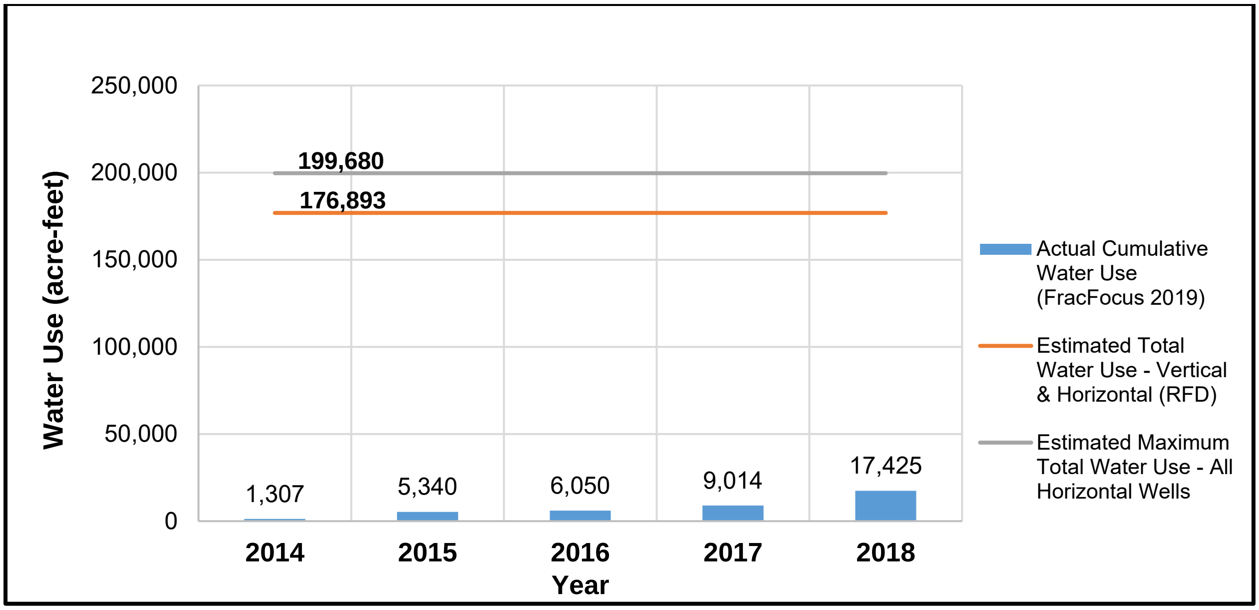
Reasonably Foreseeable Future Actions (RFFAs)

Oil and Gas Development RFFAs

RFD Scenario

Between 2012 and 2014, the BLM prepared an RFD scenario for the Pecos District that projected approximately 800 new wells per year, for a total of 16,000 wells over a 20-year period (Engler and Cather 2012; 2014). Of that total, approximately 6,400 wells would be developed on BLM-administered lands (federal surface or subsurface); the remaining 9,600 wells would be developed on state or private lands. Well development projected as a result of ongoing BLM and state lease sales is already considered in the RFD. Well development associated with recent or reasonably foreseeable Applications for Permit to Drill (APDs) or master development plans is also included in the RFD.

Figure 2.3 shows past cumulative water use between 2014 and 2018 for the 6,400 federal wells in the Permian Basin (FracFocus 2019) compared to water use estimates from the RFD scenario (Engler and Cather 2012; 2014). Two water use scenarios are depicted for the RFD. The upper end estimate (shown in grey in Figure 2.3) is derived by assuming all new wells would be horizontal. If all 6,400 wells were drilled horizontally, the total water use is estimated to be 199,680 AF, or 9,984 AF in any given year. The alternative scenario (shown in orange in Figure 2.3 is derived by using the estimated vertical and horizontal breakout of federal wells provided in the RFD (88 percent horizontal and 12 percent vertical). Under this scenario, development of 6,400 new federal wells would require 176,893 AF, or 8,845 AF in any given year



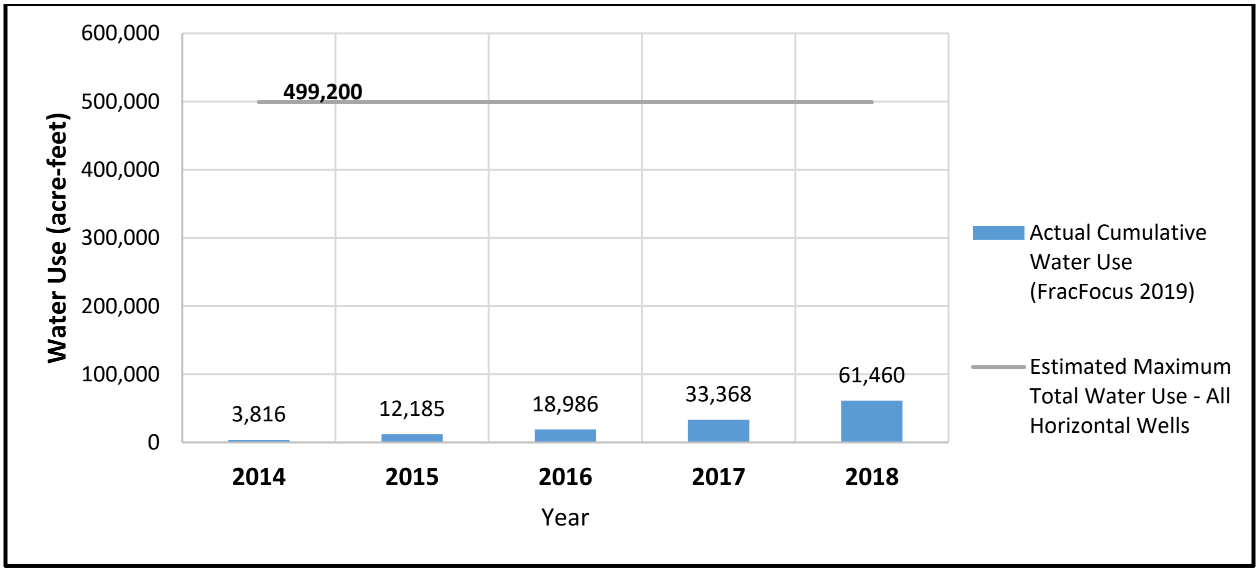
Note: Actual past cumulative federal well water use is calculated by adding the sum of all previous actual water use to the actual water use for any given year (data from 2014-2018 from FracFocus 2019). Projected water use for the federal well component of the RFD (6,400 wells; Engler and Cather 2012; 2014) is displayed for two potential scenarios providing an upper and lower end estimate of water use. The upper end estimate (shown in grey) comes from assuming all 6,400 new wells to be horizontal, while the lower end estimate (shown in orange) uses the revised water use estimates discussed in Section 2.1.2 (31.2 AF per horizontal wells), and assumes 88% of the 6,400 new wells will be drilled horizontally.

Figure 2.3. Actual Water Use (2014-2018) Compared to Projected Water Use for Federal Wells in the Permian Basin.

With consideration of the revised water use estimates presented above (31.2 AF per horizontal well), development of all 16,000 wells in the RFD (assuming all wells would be drilled horizontally) would require 499,200 AF of water, or 24,960 AF in any given year. Figure 2.4 shows actual cumulative water use between 2014 and 2018 for all wells (both federal and non-federal) in the Permian Basin (FracFocus 2019) compared to water use estimates from the RFD scenario (Engler and Cather 2012; 2014).
The upper end estimate (shown in grey in Figure 2.4) is derived by assuming all 16,000 wells in the RFD scenario would be drilled horizontally.

2019 Water Use Trends

Based on APDs received by the BLM Carlsbad Field Office and Roswell Field Office in 2019, the water use volumes for 2019 are expected to be very similar to those in 2018. In 2020, once the 2019 FracFocus actual water use data is released, these projections would be compared to the actual water use, and this report would be updated accordingly.



Note: Actual water use from FracFocus 2019. Cumulative water use for each year is calculated by adding the sum of all previous actual water use to the actual water use for any given year. The maximum water use estimate comes from assuming all new wells to be horizontal.

Figure 2.4. Actual Water Use (2014-2018) Compared to Projected Water Use for All Wells in the Permian Basin Reasonably Foreseeable Future Actions (RFFAs)

<u>Other RFFAs</u>

There are no mining RFFAs that would contribute to cumulative water withdrawals within the Pecos District. Some water use would be required during construction and operation of some reasonably foreseeable transmission lines and pipelines; these uses may vary depend on local conditions (for example, the need for dust control) and therefore are not quantified in this analysis. Future water use for the other reported water use categories in the Pecos District is assumed to continue at current levels.

Cumulative Impacts

Development of all RFFAs (as represented by the full RFD) would require 24,960 AF of water in any given year. This is about 4 percent of Pecos District Tri-County 2015 total water withdrawals (620,416 AF, which already includes past and present actions. Agriculture would remain by far the largest water use within the county (currently 75 percent of all water use within the Pecos District and 82 percent of all water use within the state).

2.1.4. Potential Sources of Water for Project Development

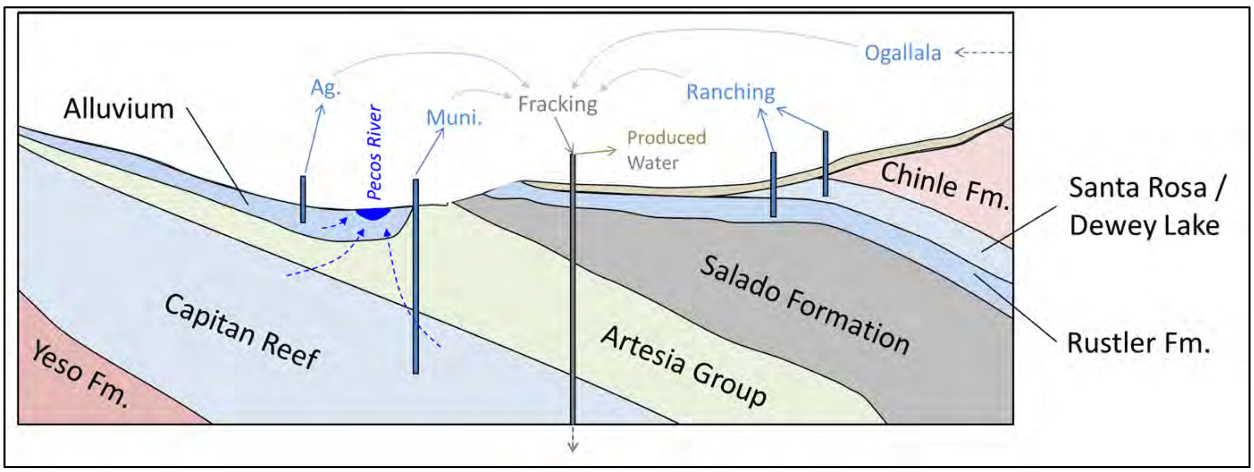
The Pecos District contains a variety of surface waters, from springs and seeps to lakes, playas, rivers, and ephemeral drainages and draws. Waters from spring developments, reservoirs or streams, and stream diversions within the planning area are used primarily for irrigation, livestock, and wildlife. No surface waters used for domestic purposes originate on BLM-managed land. Diversions on BLM-managed lands support private land crop irrigation and stock water needs. Water use associated with oil and gas drilling is primarily from groundwater. Table 2-9 shows the potential sources of groundwater in the Pecos District. Figure 2-6 is an idealized cross section of these aquifers. It is speculative to predict the actual source of water that would be used for development of the RFD (or the development of any specific lease sales). However, because approximately 88 percent of all water use and 100 percent of all mineral use in the Pecos District is currently from groundwater, it is reasonable to assume that water used for development of the RFD would likely be groundwater. Water used for oil and gas drilling and completion would be purchased legally from those who hold water rights in or around the Permian Basin.

The transaction would be handled by the New Mexico Oil Conservation Division, as well as the NMOSE. All water uses would be evaluated at the APD stage in site-specific NEPA analysis and subject to standard lease terms and conditions; however, it is important to note that sources of water for lease development are also not always known at the APD stage.

Table 2-9. Potential Sources of Groundwater in the Pecos District

Aquifer Name	Description
Pecos Valley Alluvium	Surficial deposits along the Pecos River. No known recharge areas.
Dewey Lake and Santa Rosa	Redbed sandstones. Inconsistent water source. Recharge occurs closer to the surface, as a result of weather events.
Rustler Formation (Culebra and Magenta)	Dolomite, fractured and dissolution zones. Local recharge occurs, largely as a result of weather events.
Capitan Reef	Limestone, Karstic formation. Good quality west of the Pecos, low quality towards the east. Recharge in the west occurs mainly in the vicinity of the Guadalupe Mountains. Recharge in the east occurs in the vicinity of the Glass Mountains (in Texas). The New Mexico portion of the eastern part of the Capitan Reef is recharging at a high rate.
Ogallala	Sand and gravel. Offsite aquifer where water imported to area.

Source: Lowry et al 2018.



Source: Summers 1972.

Figure 2.5. Idealized geologic cross-section of potential water sources in the Pecos District.

A recent study conducted by Sandia National Laboratory (Lowry et al. 2018) was completed in portions of Eddy and Lea Counties that were identified as having of high potential for oil and gas development in the RFD. The study was undertaken to establish a water-level and chemistry baseline and develop a modeling tool to aid the BLM in understanding the regional water supply dynamics under different management, policy, and growth scenarios and to pre-emptively identify risks to water sustainability. The following section summarizes key information in that report related to groundwater sources.

Four high potential areas (HPAs) were studied. The HPAs were associated with the Alto Platform, Bone Spring, and Delaware Mountain Group plays and were limited the extent of each to development on federal lands managed by the BLM.

Most of the wells that were sampled in each HPA appeared to have a mix of source waters, and establishing definitive signatures for each aquifer was not possible. However, evidence shows that the main water source for wells in the North HPA (which included Loco Hills and areas along the Pecos River) are from the Dewey Lake and Santa Rosa aquifer or another perched source in the host Dockum Formation. For the Center North HPA (which encompasses a region known as Burton Flats), the main sources are from the Dewey Lake and Santa Rosa aquifer and the Rustler Formation. For the South HPA (located near Malaga and Loving), the main water sources are the Dewey Lake and Santa Rosa aquifer. The east HPA, which primarily represents the Ogallala aquifer, was excluded from the study because only a small percentage of the land is managed by the BLM and because the aquifer is heavily pumped for agricultural purposes throughout several states, which would require a broader study of the overall aquifer (Lowry et al. 2018). The study also sampled wells that access water from the Capitan Reef, located near the community of Carlsbad.

Select wells were also monitored using both continuous and manual water level measurements throughout the study:

- Water levels in the two sampling water wells located in the North HPA fluctuated only slightly (>1 pounds per square inch [psi]) and carried no obvious trend, indicating a high likelihood that the water level variations are naturally occurring through seasonal and barometric pressure fluctuations.
- Of the two monitoring wells located in the Center North HPA, one showed only water level changes suggestive of barometric effects and seasonal change; the other well displayed a sharp water level increase. The cause of this change is conjectured to be from active drilling, pumping, or injecting near the well.
- Of the 16 wells monitoring the South HPA:
    - Two wells showed minimal water level change with a slight increasing trend over time, indicating that the aquifer is not being locally impacted by pumping or aquifer development.
    - Two wells showed pressure variations that are typical to nearby pumping. One well was located near a known oil supply well which is the likely driver to the drawdown and recovery response; the other was located near a municipal water supply well and its erratic response is indicative of pumping cycles associated with a small community water supply.
    - Five wells displayed water level changes that are typical for aquifers affected by seasonal variations in pressure and barometric effects.
    - Three wells showed minor water level changes likely due to activity in adjacent wells. The origins of the aquifer activity affecting each well are unknown, but likely due to oilfield drilling activities.
    - One well had drastic changes in water level as a result of nearby pumping tests conducted as part of monitoring of the Waste Isolation Pilot Plant (WIPP).
    - Three wells displayed water level changes due to high production pumping by a local ranch.
- Of the five wells monitoring the Capitan Reef, two wells recorded pressure decreases. The source of the pressure change is undetermined; however, it is likely these wells are influenced by precipitation given their shallow depth and the karstic nature of the formation, as well as from localized municipal pumping by the City of Carlsbad. The remaining three wells recorded water levels increasing at a relatively constant rate. This suggests that the aquifer in the eastern part of the Capitan Reef is experiencing recharge.

A model is being developed as part of the Sandia Report to simulate water availability over a range of different future scenarios, including drilling activity and water demand to identify areas that are most vulnerable and to estimate the risk to water sustainability. The model is still under development, but when completed, it will allow BLM to look at the balances between water demand and water availability to predict and track both risks to each aquifer as well as calculate well drawdown. The intent is to screen future water extraction that may be unsustainable. The Carlsbad FO will have the capacity to apply this model during future NEPA actions.

2.1.5. Water Use Mitigations

Overall, there have been calls to increase the use of alternative water sources such as brackish water or recycling produced water, minimizing the strain on local freshwater resources (Kondash et al. 2018). The BLM encourages the use of recycled water in hydraulic fracturing techniques.

Moreover, recent studies indicate that the water used for hydraulic fracturing may be retained within the shale formation, with only a small fraction of the fresh water injected into the ground returning as flowback water; water returning to the surface is highly saline, is difficult to treat, and is often disposed through deep-injection wells (Kondash et al. 2018). Thus, the ability to recycle water may be more limited than previously reported. Note that the water use calculations above do not assume the use of recycled water.

2.2. Water Quality

2.2.1. Groundwater

As noted in Section 2.1, the BLM contracted with Sandia National Laboratory to prepare a report (Lowry et al. 2018) on water sustainability in the Permian Basin related to oil and gas development. The following section summarizes key information in the report related to groundwater quality.

Total dissolved solids (TDS) concentration is a measure of all the dissolved matter in a sample of water. TDS is the primary indicator of groundwater quality as higher TDS concentrations typically make water less suitable for drinking or for agricultural purposes like irrigation. In groundwater, TDS is influenced by the dissolution of natural materials such as rock, soil, and organic material. Anthropogenic activities also contribute to TDS concentrations in shallow unconfined aquifers. Groundwater quality in Eddy and Lea Counties and in the Lower Pecos Valley varies considerably depending on the aquifer and location. In general, groundwater on the west side of the Pecos River is fresher than groundwater on the river’s east side. East of the Pecos River, salinity is higher and can reach concentrations of 35,000 milligrams per Liter (mg/L). Shallow groundwater quality can be very good in the alluvial aquifers, but of poor quality in deeper geologic formations due to the presence of salt, gypsum, and other evaporite deposits. Groundwater tends to be mineralized or ‘hard’ west of the Ogallala aquifer (Lowry et al. 2018). Typical ranges of total dissolved solids (TDS) along with the general aquifer materials are shown in Table 2-9.

Table 2-10. Typical TDS Ranges Found in the Main Aquifers of the Pecos District

Aquifers	Aquifer Material	Typical TDS Range (mg/L)
Pecos	Alluvium	<200 to 10,000
Rustler (includes Culebra and Magenta)	Carbonates and Evaporites	<1,000 to 4,600
Dockum (includes Dewey Lake and Santa Rosa)	Sandstone and Conglomerates	<5,000 to >10,000
Capitan Reef	Dolomite and Limestone	300 to >5,000

Source: Lowry et al. 2018.

Overall 30 wells in the South HPA, 11 wells in the Center North HPA, and 19 wells in the North HPA were selected for water quality analysis. The predominant water types for each of the HPAs and the Capitan Reef are listed below

1. North – calcium and magnesium dominant
2. Center North – sodium and calcium dominant
3. South – sodium and calcium dominant
4. WIPP – sodium and chloride dominant
5. Capitan Reef – sodium dominant

The samples were also compared to the New Mexico Water Quality Control Commission (NMWQCC) human health, domestic water supply, and irrigation use standards for groundwater with a TDS concentration of 10,000 mg/L or less (20.6.2.3103 New Mexico Administrative Code [NMAC]). Table 2-10 presents a listing of the sampled water quality parameters by HPA against the NMWQCC standards for drinking water.

Table 2-11. Sampled Water Quality Parameters Against NMWQCC Drinking Water Standards

Parameter	NMWQCC Standard	North HPA	Central North HPA	South HPA and WIPP	Capitan Reef
pH (pH units)	6 to 9	7.07 - 7.97	7.53 - 7.97	6.18 - 8.59	8.08 - 8.86
Specific Conductance (µmhos/cm)	--	1000 - 3905	1300 - 83000	600 - 270000	2770 - 174500
Total Dissolved Solids (TDS)	1000	331 - 3550	869 - 43000	322 - 330000	1951 - 141875
Calcium (Ca2+)	--	0.73 - 590	2.6 - 920	0.7 - 1900	1.4 - 5902
Magnesium (Mg2+)	--	23 - 200	44 - 1492	2.10 - 10000	82.26 - 1420
Sodium (Na+)	--	18 - 262	92.58 - 12000	26 - 95000	225 - 46700
Potassium (K+)	--	0 - 30	4 - 1136	0 - 21000	6.58 - 3352
Chloride (Cl-)	250	16 - 1000	97 - 21000	11 - 190000	388.80 - 82602.1
Alkalinity (CaCO3)	--	139 - 312	19.9 - 181.2	23 - 297.10	18.53 - 250.10
Bicarbonate (HCO3-)	--	139 - 312	19.8 - 181.2	39.72 - 297.10	18.74 - 249.27
Carbonate (CO3-)	--	0 - <2	0 - <2	0 - 16.08	0 - 0.83
Sulfate (SO42-)	600	0 - 1900	306.71 - 6400	0 - 15000	0 - 1975.67
Fluoride (F-)	1.6	0 - 1.3	0.82 - 2.60	0.00 - 3.63	0.09 - 0.52
Nitrite (NO2)	10	0 - 6.27	0 - 8.8	0.00 - 20.08	0.05 - 7.60
Nitrate (NO3)	10	0 - 10	2.6 - 8.8	0 - 19	0.04 - 7.60
Silver (Ag)	0.05	--	--	--	0
Aluminum (Al)	5	--	0.18	0 – 4.06	--
Arsenic (As)	0.1	0.02 – 0.06	0.03 - 0.32	0 – 0.29	0.10
Barium (Ba)	1	0.01 – 0.13	0.01 - 0.03	0- 0.1	0.02 - 0.25
Bromide (Br)	--	0 - 7.8	0.28 - 12.00	0 - 1400	0.3 - 12.73
Cadmium (Cd)	0.01	--	--	--	--
Copper (Cu)	1	0.02	0.03	0.06 - 0.37	--
Iron (Fe)	1	3.34	0.04	0.01 - 1.62	3.41
Lithium (Li)	--	0.14 - 1.70	0.140 - 1.695	0.05 - 0.85	0.04 - 4.49
Manganese (Mn)	0.2	0 - 0.06	0 - 0.20	0 - 0.06	0 - 7.61

Parameter	NMWQCC Standard	North HPA	Central North HPA	South HPA and WIPP	Capitan Reef
Nickel (Ni)	0.2	--	0 - 0.02	0 - 0.01	0.01
Lead (Pb)	0.05	0.04	--	0.02 - 0.06	--
Silicon (Si)	--	2.67 - 18.38	1.9 - 23.4	4.91 - 47.0	0 - 7.10
Strontium (Sr2+)	--	0.63 - 8.47	2.73 - 13.75	0.05 - 32.0	2.52 - 104.8
Vanadium (V)	--	--	0.01 - 0.03	0 - 0.1	--

Source: Lowry et al. 2018.
Notes: Units are milligrams per liter (mg/L) unless otherwise noted. "—" = not applicable or not detected. Values rounded to two decimal places.

Key observations related to the comparison of results to the standards:

- Seventeen of the water quality parameters analyzed have applicable NMWQCC standards: pH, TDS, Cl-, SO42-, F-, NO3-+ NO2-, Ag, Al, As, Ba, Cd, Cr, Cu, Fe, Mn, Ni, Pb.
- No exceedances were observed for eight of the parameters with NMWQCC standards: pH, Ag, Al, Ba, Cd, Cr, Cu, and Ni.

2.2.2. Surface Water

Stream and river conditions vary widely, from completely undisturbed river and vegetative communities in the mountainous highlands, to deep, erodible soil banks at lower elevations where livestock, recreationists, and other public users have access to streams and riverbanks.

Water quality in streams flowing on BLM-managed land is influenced by both natural water quality with regard to salinity content and the intensity of human and industrial activity in the watershed. For example, water quality may be vastly different in a remote mountain spring creek than in waters with natural brine discharge, or where there are human impacts due to urban, farming, ranching, or industrial activity. Chemistry samples of surface water in the planning region are needed in order to establish a baseline chemistry data for the waters. Variances in baseline chemistry can indicate water quality changes attributable to land use development. The most common pollutants for waters in the planning area are sediment and mercury. Beneficial uses listed for these waters are industrial water supply, irrigation storage, livestock watering, recreation, warm water fishery, and wildlife habitat. The dominant legislation affecting national water quality and BLM compliance with New Mexico water quality requirements is the Clean Water Act (CWA) or Federal Water Pollution Control Act. Within the planning area, total maximum daily loads (TMDLs) determinations are not in place for any of the watersheds with 303(d)-listed streams. Thus, an assessment of their condition via this metric is not possible at the time.

2.2.3. Potential Sources of Surface Water or Groundwater Contamination

Spills

Spills associated with oil and gas development may reach surface water directly during the spill event. Spills may also reach surface waters indirectly, when the spill has occurred, and a rain event moves contaminants into nearby surface water bodies through surface water flow or even subsurface groundwater flow into springs that discharge into a surface water body.

There are approximately 15,660 federal wells within the New Mexico portion of the Permian Basin. planning area (BLM 2018). As shown in Table 2-11, there were a total of 1,261 spills in the Permian Basin in 2018. The rate of recovery varies by spill type but, in general, most spills are not recovered. No spills occurring in the Pecos District were reported as having affected surface or groundwater. Appendix C contains the methodology for spill analysis.

The BLM works with the State of New Mexico Oil Conservation Division (NMOCD) to remediate spills on public BLM lands. Per NMAC 19.15.29.11, the responsible person shall complete division-approved corrective action for releases that endanger public health or the environment in accordance with a remediation plan submitted to and approved by the division or with an abatement plan submitted in accordance with 19.15.30 NMAC. The remaining contaminates from unrecovered spills are remediated in accordance with federal and state standards. Some remediation consists of removing contaminated soil and replacing it with uncontaminated soil and corresponding chemical testing.

Table 2-12. Summary of 2018 Spills in the New Mexico Portion of the Permian Basin

Material Type	Count of Spills	Volume Spilled	Volume Lost	Units	% Lost
Acid	1	20	1	Barrels	5%
Basic sediment and water (BS&W)	5	19	9	Barrels	47%
Brine Water	3	1,570	1,531	Barrels	98%
Chemical	9	1,342	1,165	Barrels	87%
Condensate	13	405	258	Barrels	64%
Crude Oil	435	15,388	6,595	Barrels	43%
Diesel	3	24	16	Barrels	67%
Drilling Mud/Fluid	6	615	353	Barrels	57%
Other	26	15,049	14,060	Barrels	93%
Produced Water	606	90,931	44,775	Barrels	49%
Sulphuric Acid	1	20	15	Barrels	75%
Total	**1,108**	**125,383**	**68,778**	**Barrels**	**55%**
Natural Gas (Methane) and Natural Gas Liquids	153	144,813	144,813	MCF	100%
Total Number of Spills	**1,261**				

Source: NMOCD 2019.
Note: MCF is one thousand cubic feet

Drilling and Completion Activities

The BLM and NMOCD has casing, cementing, and inspection requirements in place to limit the potential for groundwater reservoirs and shallow aquifers to be impacted by fracking or the migration of hydrocarbons on the nominated lease parcels. Prior to approving an APD, a BLM geologist would identify all potential subsurface formations that would be penetrated by the wellbore including groundwater aquifers and any zones that would present potential safety or health risks that would need special protection measures during drilling, or that could require specific protective well construction measures. Casing programs and cement specifications would be submitted to the BLM and NMOCD for approval to ensure that well construction design would be adequate to protect the subsurface environment, including known or anticipated zones with potential risks or zones identified by the geologist. Surface casing would be set to an approved depth, and the well casing and cementing would stabilize the wellbore and provide protection to any overlying freshwater aquifers by isolating hydrocarbon zones from overlying freshwater aquifers. Before hydraulic fracturing takes place, all surface casings and intermediate zones would be required to be cemented from the bottom of the cased hole to the surface. The cemented well would be pressure tested to ensure there are no leaks, and a cement bond log would be run to confirm that the cement has bonded to the steel casing strings and to the surrounding formations.

The BLM requires operators to comply with the regulations at 43 Code of Federal Regulations (CFR) 3160. These regulations require oil and gas development to comply with directives in the Onshore Orders and the orders of the Authorized Officer. Onshore Order No. 2 and the regulations at 43 CFR 3162.3-3 provide regulatory requirements for hydraulic fracturing, including casing specifications, monitoring and recording, and management of recovered fluids. The State of New Mexico also has regulations for drilling, casing and cementing, completion, and plugging to protect freshwater zones (19.15.16 New Mexico Administrative Code). Complying with the aforementioned regulations requires producers and regulators to verify the integrity of casing and cement jobs. Casing specifications are designed and submitted to the BLM together with an APD. The BLM petroleum engineer independently reviews the drilling plan and, based on site-specific geologic and hydrologic information, ensures that proper drilling, casing, and cementing procedures are incorporated in the plan in order to protect usable groundwater. This isolates usable water zones from drilling, completion/hydraulic fracturing fluids, and fluids from other mineral bearing zones, including hydrocarbon bearing zones. Conditions of Approval (COAs) may be attached to the APD if necessary to ensure groundwater protection. Installations of the casing and cementing operations are witnessed by certified BLM Petroleum Engineering Technicians. At the end of the well's economic life, the operator must submit a plugging plan. The plugging plan is reviewed by the BLM petroleum engineer prior to well plugging, and ensures permanent isolation of usable groundwater from hydrocarbon bearing zones. BLM inspectors ensure planned procedures are properly followed in the field.

Surface casing and cement would be extended beyond usable water zones. Production casing will be extended and adequately cemented within the surface casing to protect other mineral formations, in addition to usable water bearing zones. These requirements ensure that drilling fluids, hydraulic fracturing fluids, and produced water and hydrocarbons remain within the well bore and do not enter groundwater or any other formations. Since the advent of hydraulic fracturing, more than 1 million hydraulic fracturing treatments have been conducted, with perhaps only one documented case of direct groundwater pollution resulting from injection of hydraulic fracturing chemicals used for shale gas extraction (Gallegos and Varela 2015). Requirements of Onshore Order No. 2 (along with adherence to state regulations) make contamination of groundwater resources highly unlikely, and there have not been any documented past instances of groundwater contamination attributed to well drilling. This is an indication of how effective the use of casing and cement is at preventing leaks and contamination.

CHAPTER 3. FARMINGTON FIELD OFFICE

Located in north-central New Mexico, the Farmington Field Office (FO) includes approximately 1.4 million acres of public lands, and encompasses all of San Juan County, most of McKinley County, western Rio Arriba County, and northwestern Sandoval County. The Farmington FO is also a part of the New Mexico portion of the San Juan Basin, an oil and gas basin that is in the northwestern portion of New Mexico and the southwestern portion of Colorado (BLM 2003).

Chapter 3 outlines existing and projected (reasonably foreseeable) water quantity and water quality for the Farmington FO based on information gathered from the following sources: 1) the Farmington Resource Management Plan and Final Environmental Impact Statement (BLM 2003), 2) the Reasonable Foreseeable Development Scenario for Oil and Gas Activities, Mancos-Gallup RMPA Planning Area, Farmington Field Office, northwestern New Mexico ("2018 RFD", Crocker and Glover 2018), 3) data compiled from a 2015 USGS report, Estimated Use of Water in the United States in 2015 (Dieter et. al. 2018), and 4) FracFocus, a national hydraulic fracturing chemical registry managed by the Ground Water Protection Council and Interstate Oil and Gas Compact Commission (FracFocus 2018).

3.1. Water Quantity

Sections 3.1.1 and 3.1.2 detail water quantity, existing groundwater use, and water use associated with oil and gas development and hydraulic fracturing operations in the Farmington FO and the New Mexico portion of the San Juan Basin.

3.1.1. Existing Surface and Groundwater Water Use

Farmington FO Water Use (Rio Arriba County, San Juan County, Sandoval County, and McKinley County)

The 2015 USGS Report, Estimated Use of Water in the United States in 2015 (Dieter et. al. 2018), lists total water withdrawals for the counties comprising the Farmington FO across eight water use categories: aquaculture, domestic, industrial, irrigation, livestock, mining, public water supply, and thermoelectric power. Water use totals (in acre feet per year [AF/yr]) for each of these industries are summarized by surface water and groundwater, which is further divided into fresh water and saline water use for each category.

Table 3-1 through Table 3-4 list the total 2015 water withdrawals for the eight water use categories as reported by USGS (Dieter et al. 2018) for each of the counties within the Farmington FO: Rio Arriba, San Juan, Sandoval, and McKinley.

In Rio Arriba County, where most of the oil and gas development is expected to take place within the Farmington FO, irrigation is the largest category of water use in Rio Arriba County, accounting for an average of 93 percent (109,129 acre-feet [AF]) of the total water withdrawal for Rio Arriba County (118,120 AF, Table 3-1). Approximately 8 percent (9,698 AF) of the total water use for Rio Arriba County is from groundwater. Mining (which includes oil and gas development) comprises approximately 1 percent of Rio Arriba County water withdrawals. All mining-related water use (1,682 AF) is from groundwater; of that total, 74 percent of withdrawals is from saline sources. The relative use of water by industry within Rio Arriba County is depicted in Figure 3-1. The relative use of surface water and fresh/saline groundwater by industry within Rio Arriba County is depicted in Figure 3-2.

In San Juan County, Irrigation accounts for 79 percent (223,942 AF/yr) of the total water withdrawal in San Juan County (283,748 AF/yr; Table 3-2). *Mining* accounts for 2 percent (6,356 AF/yr) of total water withdrawals in the county.

In Sandoval County, Mining accounts for 2 percent (1,312 AF/yr) of the total water use **(**Table 3-3**)**. All water used by mining activities in Sandoval County comes from groundwater. The largest water use categories in Sandoval County are irrigation (79 percent), followed by public water supply (8 percent). Most drilling activities in Sandoval County are expected to take place in the northwest corner of the county, which falls within the San Juan Basin where there is a much greater development potential for oil and gas than in other areas of the county. This determination is based on a 2018 report submitted to the Sandoval County Planning and Zone Commission about the oil and natural gas potential of Sandoval County, which included a discussion on the potential for aquifer contamination (Broadhead et al. 2018). According to this report, the oil and gas development in Sandoval County has thus far occurred in the northern part of the county that is within the San Juan Basin. This trend is likely to continue because "oil and gas potential decreases southward primarily because petroleum source rocks, including the Mancos Shale, become less mature in this direction" (Broadhead et al. 2018:8).

Consumptive water use from mining activities in McKinley County accounts for 17 percent (2,309 AF/yr) of the total water use (Dieter et al. 2018) for the county (13,217 AF/yr, Table 3-4). The 2015 USGS data show water use by county, not by BLM field office boundary; therefore, it is not known if mining activities accounting for 17 percent of the total water use are within the Farmington FO or within the neighboring Rio Puerco FO.

San Juan Basin (Sandoval, Rio Arriba, McKinley, and San Juan Counties)

Table 3-5 summarizes the water withdrawals within the San Juan Basin, which is comprised of Sandoval, Rio Arriba, McKinley, and San Juan Counties, because the San Juan Basin presents the highest potential for oil and gas development in the Farmington FO. The 2018 Reasonably Foreseeable Development (RFD) scenario states that "unless significant new oil and gas discoveries are made in the area, future activity will be primarily horizontal drilling for oil in the Mancos-Gallup play, with minor development targeted at natural gas production" (Crocker and Glover 2018:2). In 2015 water withdrawals for the mining category accounted for 2 percent of the total water use in the San Juan Basin. Most of the mining water was saline groundwater.

Table 3-1. Rio Arriba County 2015 Water Use by Category (AF)

Category	Surface Water				Groundwater				Total Water			
	Fresh	Saline	Total Surface Water	% of Total Water	Fresh	Saline	Total Groundwater	% of Total Water	Total Fresh Water	Total Saline Water	Total Water	% of Total Water
Aquaculture	0	0	0	0	3,554	0	3,554	100%	3,554	0	3,554	3%
Domestic	0	0	0	0	1,345	0	1345	100%	1,345	0	1,345	1%
Industrial	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation	107,874	0	107,874	99%	1,256	0	1,256	1%	109,129	0	109,129	93%
Livestock	168	0	168	47%	191	0	191	53%	359	0	359	0%
Mining	0	0	0	0	437	1,244	1,682	100%	437	1,244	1,682	1%
Public Water Supply	381	0	381	19%	1,670	0	1,670	81%	2,051	0	2,051	2%
Thermoelectric Power	0	0	0	0	0	0	0	0	0	0	0	0
County Totals	**108,423**	**0**	**108,423**	**92%**	**8,453**	**1,244**	**9,698**	**8%**	**116,875**	**1,244**	**118,120**	**100%**

Source: Dieter et al. 2018.

Table 3-2. San Juan County 2015 Water Use by Category (AF)

Category	Surface Water				Groundwater				Total Water			
	Fresh	Saline	Total Surface Water	% of Total Water	Fresh	Saline	Total Groundwater	% of Total Water	Total Fresh Water	Total Saline Water	Total Water	% of Total Water
Aquaculture	0	0	0	0%	0	0	0	0%	0	0	0	0%
Domestic	0	0	0	0%	1,312	0	1,312	100%	1,312	0	1,312	0%
Industrial	0	0	0	0%	22	0	22	100%	22	0	22	0%
Irrigation	223,942	0	223,942	100%	0	0	0	0%	223,942	0	223,942	79%
Livestock	67	0	67	18%	303	0	303	82%	370	0	370	0%
Mining	2,724	0	2,724	43%	549	3,083	3,632	57%	3,273	3,083	6,356	2%
Public Water Supply	21,097	0	21,097	100%	11	0	11	0%	21,108	0	21,108	7%
Thermoelectric Power	30,637	0	30,637	100%	0	0	0	0%	30,637	0	30,637	11%
County Totals	**278,468**	**0**	**278,468**	**98%**	**2,197**	**3,083**	**5,280**	**2%**	**280,665**	**3083**	**283,748**	**100%**

Source: Dieter et. al. 2018.

Table 3-3. Sandoval County 2015 Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% of Total Water**
Aquaculture	0	0	0	0%	1,087	0	1,087	100%	1,087	0	1,087	1%
Domestic	0	0	0	0%	3,128	0	3,128	100%	3,128	0	3,128	2%
Industrial	0	0	0	0%	2,578	0	2,578	100%	2,578	0	2,578	1%
Irrigation	48,326	0	48,326	95%	2,3201	0	2,321	5%	50,647	0	50,647	79%
Livestock	101	0	101	45%	123	0	123	55%	224	0	224	0%
Mining	0	0	0	0%	1,065	247	1,312	77%	1,065	246.6	1,312	2%
Public Water Supply	135	0	135	55%	12,466	0	12,466	45%	12,600	0	12,600	8%
Thermoelectric Power	0	0	0	0%	0	0	0	0%	0	0	0	7%
County Totals	**48,562**	**0**	**48,562**	**90%**	**22,768**	**247**	**23,014**	**32%**	**71,329**	**246.6**	**71,576**	**100%**

Source: Dieter et al. 2018

Table 3-4. McKinley County 2015 Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% of Total Water**
Aquaculture	0	0	0	0%	0	0	0	0%	0	0	0	0%
Domestic	0	0	0	0%	3,195	0	3,195	100%	3,195	0	3,195	24%
Industrial	0	0	0	0%	34	0	34	100%	34	0	34	<1%
Irrigation	1,099	0	1,099	100%	0	0	0	0%	1,099	0	1,099	8%
Livestock	101	0	101	21%	370	0	370	79%	471	0	471	4%
Mining	0	0	0	0%	1,626	684	2,309	100%	1,626	684	2,309	17%
Public Water Supply	0	0	0	0%	3,811	0	3,811	100%	3,811	0	3,811	29%
Thermoelectric Power	0	0	0	0%	2,298	0	2,298	100%	2,298	0	2,298	17%
County Totals	**1,200**	**0**	**1,200**	**9%**	**11,333**	**684**	**12,017**	**91%**	**12,533**	**684**	**13,217**	**100%**

Source: Dieter et al. 2018

Table 3-5. San Juan Basin 2015 Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% of Total Water**
Aquaculture	0	0	0	0%	4,641	0	4,641	100%	4,641	0	4,641	1%
Domestic	0	0	0	0%	8,979	0	8,979	100%	8,979	0	8,979	2%
Industrial	0	0	0	0%	2,634	0	2,634	100%	2,634	0	2,634	1%
Irrigation	381,241	0	381,241	99%	3,576	0	3,576	1%	384,817	0	384,817	79%
Livestock	437	0	437	31%	987	0	987	69%	1,424	0	1,424	<1%
Mining	2,724	0	2,724	23%	3,677	5,258	8,934	77%	6,401	5,258	11,658	2%
Public Water Supply	21,6123	0	21,613	55%	17,958	0	17,958	45%	39,571	0	39,571	8%
Thermoelectric Power	30,637	0	30,637	93%	2,298	0	2,298	7%	32,935	0	32,935	7%
Basin Totals	**436,652**	**0**	**436,652**	**90%**	**44,750**	**5,258**	**50,008**	**10%**	**481,402**	**5,258**	**486,660**	**100%**

Source: Dieter et al. 201

State of New Mexico Water Use

In 2015, withdrawals for all water use categories across the State of New Mexico totaled 3,249,667 AF (Dieter et. al 2018). The New Mexico portion of the San Juan Basin water use totals (486,660 AF) accounted for about 15 percent of total 2015 statewide withdrawals. Table 3-6 presents water use associated with oil and gas development in New Mexico, by county. As shown in the table, over 99 percent of the water use associated with oil and gas development occurs in the Pecos District (Chaves, Eddy, and Lea Counties [3,994 AF]), in the Permian Basin.

Table 3-6. 2015 State of New Mexico Water Use Associated with Oil and Gas Development

County	Surface Water	Groundwater	Total	% of Total
Bernalillo	0	7	7	0%
Chaves	0	84	84	2%
Eddy	0	2,635	2,635	65%
Lea	0	1,275	1,275	32%
Rio Arriba	0	0	0	0%
Sandoval	0	0	0	0%
San Juan	30	0	30	0.7%
Sierra	0	1	1	0%
State total	30	4,002	4,032	100%

Source: NMOSE 2019

Table 3-7 lists the water withdrawals for the major industries in New Mexico. As shown in the table, *Mining* water withdrawals totaled 163,901 AF, or about 5 percent of the total water withdrawals for the State of New Mexico. It is important to note that *Mining* accounts for all withdrawals of a variety of mining activities, and oil and gas development is only a small portion of this percentage.

Table 3-7. State of New Mexico Water Use by Category (AF)

Category	Surface Water				Groundwater				Total Water			
	Fresh	Saline	Total Surface Water	% of Total Water	Fresh	Saline	Total Groundwater	% of Total Water	Fresh	Saline	Total Water	% of Total Water
Aquaculture	6,109	0	6,109	23%	20,929	0	20,929	77%	27,039	0	27,039	1%
Domestic	0	0	0	0%	27,621	0	27,621	100%	27,621	-	27,621	1%
Industrial	0	0	0	0%	3,811	0	3,811	100%	3,811	0	3,811	0%
Irrigation	1,485,112	0	1,485,112	56%	1,175,312	0	1,175,312	44%	2,660,424	0	2,660,424	82%
Livestock	2,522	0	2,522	7%	33,372	0	33,372	93%	35,894	0	35,894	1%
Mining†	19,550	0	19,550	12%	44,111	100,240	144,351	88%	63,662	100,240	163,901	5%
Public Water Supply	87,752	0	87,752	30%	205,715	0	205,715	70%	293,467	0	293,467	9%
Thermoelectric Power	30,637	0	30,637	82%	6,872	0	6,872	18%	37,509	-	37,509	1%
State-wide Totals	**1,631,683**	**0**	**1,631,683**	**50%**	**1,517,744**	**100,240**	**1,617,984**	**50%**	**3,149,427**	**100,240**	**3,249,667**	**100%**

Source: Source: Dieter et al. 2018; updated with additional information provided to the BLM from the NMOSE regarding water use of the Navajo Power Plant (BLM 2019a).

† Approximately 19,550 AF of the freshwater use within the Mining industry is from surface water; the remainder of all other water use is from groundwater. The Mining category includes the following self-supplied enterprises that extract minerals occurring naturally in the earth's crust: solids, such as potash, coal, and smelting ores; liquids, such as crude petroleum; and gases, such as natural gas. This category includes water used for oil and gas production (well drilling and secondary recovery of oil), quarrying, milling (crushing, screening, washing, flotation, etc.), and other processing done at the mine site or as part of a mining activity, as well as water removed from underground excavations (mine dewatering) and stored in—and evaporated from—tailings ponds. The Mining category also includes water used to irrigate new vegetative covers at former mine sites that have been reclaimed. It does not include the processing of raw materials, such as smelting ores, unless this activity occurs as an integral part of a mining operation and is included in an NMOSE permit.

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3.1.2. Water Use Associated with Reasonably Foreseeable Oil and Gas Development

The 2018 RFD (Crocker and Glover 2018) was used to forecast the potential quantity of oil and gas wells in the Mancos-Gallup Resource Management Plan Amendment (RMPA) Planning Area, which includes most of the Farmington FO and is where most potential oil and gas development is assumed to occur. The RFD was also used to forecast estimates of the quantity of water that would be required for hydraulic fracturing of the forecasted wells. These water use estimates assume that 100% of wells will be hydraulically fractured, and do not account for re-use or recycling of hydraulic fracturing fluid.

The 2018 RFD (Crocker and Glover 2018) is a reasonable estimate of the development and consumptive water use associated with hydrocarbon production in the New Mexico portion of the San Juan Basin for the next 20 years (2018–2037). According to the 2018 RFD 3,200 wells are expected to be drilled in the planning area between 2018 and 2037 based on actualized data. Water use associated with hydraulic fracturing is dependent on many factors, including (but not limited to) the drilling method (horizontal or vertical) and the geologic formation at the well site. Of the 3,200 wells projected to be drilled between 2018 and 2037, 2,300 are expected to be horizontal and 900 are expected to be vertical.

The 2018 RFD (Crocker and Glover 2018) scenario utilizes water use estimates from a 2014 RFD scenario prepared by the New Mexico Bureau of Geology and Mineral Resources entitled *Hydrologic Assessment of Oil and Gas Resource Development of the Mancos Shale in the San Juan Basin* by Kelley et al. (2014). According to Kelley et al. (2014:4), "vertical wells drilled into the Mesaverde Group, Gallup Sandstone, and the Dakota Sandstone account for 83 percent of the hydraulically fractured completions [in the San Juan Basin] since 2005."

Water use associated with hydraulic fracturing is dependent on many factors, including the geologic formation. On average, the water use for vertical wells in the New Mexico portion of the San Juan Basin is 0.537 AF/well (Crocker and Glover 2018). Horizontal wells require more water than vertical wells. The 2018 RFD (Crocker and Glover 2018) reported that horizontal wells in the San Juan Basin require on average approximately 3.13 AF of water. More recent information on horizontal well development in the San Juan Basin has indicated water use is higher. Because of this uncertainty, the BLM conducted studies using calendar year 2018 data from FracFocus, a national hydraulic fracturing chemical registry managed by the Ground Water Protection Council and Interstate Oil and Gas Compact Commission, to provide objective information on hydraulic fracturing. Operators are required by the State of New Mexico to disclose chemistry and water use information on FracFocus. Analysis of 2018 FracFocus data for the New Mexico portion of the San Juan Basin (which included 126 records) resulted in a value of 4.8 AF of water per horizontal well completion. As a result of these studies, the BLM considers the estimate of 4.8 AF the most accurate current estimate of water use per horizontal well completions in the San Juan Basin based on historical data. Table 3-8 provides a comparison of the water use estimates used in the 2018 RFD and the BLM's revised water use estimates. Some factors have been modified based on best available information (for example, the projected water use associated with horizontal drilling methods discussed above) as well as best professional judgment of BLM engineering staff and resource specialists.

Table 3-8. Projected Water Use (AF) in San Juan Basin (Farmington FO)

Factor	Water Use in RFD (Crocker and Glover 2018)	Revised Water Use	Rationale for Change
Average Water Use per Horizontal Well during a hydraulic fracturing operation	3.13 AF	4.84 AF[1]	Reflects actual use as reported in FracFocus
Average Water Use per Vertical Well during a hydraulic fracturing operation	0.537 AF	0.537 AF[2]	No change
Total Water Use (2018-2037)	**7,683 AF[3]**	**11,615 AF[3]**	

[1]Source: Derived from Crocker and Glover 2018.
[2] Source: FracFocus, 2018
[3] Source: BLM 2019b
[4] Total water use = (2,300 horizontal wells[1] * horizontal well water use estimate) + (900 vertical wells[1] * vertical well water use estimate)
Note: AF is acre-feet.

Water used for hydraulic fracturing of the estimated 3,200 wells in the 2018 RFD (Crocker and Glover 2018) is assumed to come primarily from fresh groundwater sources based on historic oil and gas development in the area and from county water use data summarized in Table 3-1 through Table 3-5 above (Dieter et al. 2018). Drilling and completion of the 3,200 wells estimated to occur in the planning area would require approximately 7,683 AF using the water use estimates contained in the Crocker and Glover RFD scenario. Using the BLM's revised water use estimates discussed above (4.84 AF per horizontal well), development of the 3,200 wells in the 2018 RFD would require 11,615 AF of water, or 580 AF of water in any given year. The estimated amount of water needed to develop the RFD in any given year (580 AF) is approximately 0.12 percent of the 2015 water use in the San Juan Basin.

Water use could increase if more water-intensive stimulation methods (e.g., slick water fracturing) are implemented or if laterals become longer. Alternatively, water use estimates could be lower if produced water is reused or recycled for use in hydraulic fracturing. Additionally, as technology changes, other sources of water become available for use.

3.1.3. Water Use Associated with Slick Water Stimulation

Fluid mineral development in the New Mexico portion of the San Juan Basin has experienced technological advances with the introduction of slick water stimulation beginning in 2015. Since the development of the 2018 RFD (Crocker and Glover 2018), additional information regarding the slick water stimulation technique has been gathered by the Farmington FO through outreach conducted with local operators actively drilling and producing mineral resources in the New Mexico portion of the San Juan Basin. To date, 20 wells have been drilled using long laterals with slick-water stimulation within the Farmington FO. Horizontal well bores are stimulated in intervals, each interval is called a stage. For the 20 completed wells, the Farmington FO calculated the average stage length to be 200 feet and the average water used per stage to stimulate the formation to be 334,000 gallons (~ 1 acre-foot). The equation for calculating estimated water volume is indicated below:

(Total water volume) = (stage water volume/stage length) x (number of stages/lateral length)

According to data from FracFocus, the average water use associated with slick water stimulation of the 20 wells was 41 AF. Using this information, and an average lateral well bore of 1.5 miles (as obtained from the corresponding APDs), the BLM has calculated an average of 27 AF per lateral mile. Table 3-9 provides a summary of average number of stages dependent on length of well bore and the average water use to complete 1- to 3- mile laterals.

Table 3-9. Average Volume of Water Required to Complete 1-3 Mile Laterals Utilizing Slick Water Stimulation in the Mancos Shale and Gallup Sandstone Formations

Miles	Number of Stages	Acre Feet
1	26	27
1.5	39	40
2	52	53
2.5	65	67
3	78	80

Current technology allows operators to utilize water with TDS of 50,000 ppm for use in slick water stimulation activities, well above the NMOSE potable water threshold of 1,000 ppm. This allows for the use of currently non-traditional water sources, including the connate water, recycled flowback water, and produced water. Appendix C contains additional background information on slick water fracturing in the Farmington FO as well as information regarding the methodology for capturing information and calculating water use by stage.

3.1.4. Cumulative Water Use Estimates

Past and Present Actions

Past and present use is discussed above in Section 3.1.1, Existing Surface and Groundwater Use. As noted in that section, total water use in the counties comprising the New Mexico portion of the San Juan Basin (486,660 AF) accounted for 15 percent of total state withdrawals (3,249,667 AF) in 2015 (Dieter et al. 2018). Mining (which includes oil and gas development) comprised about 2 percent of San Juan Basin total water withdrawals. The largest user of water in the New Mexico portion of the San Juan Basin is irrigation (comprising 79 percent of all withdrawals in the New Mexico portion of the San Juan Basin).

The BLM also examined FracFocus data reported for the calendar years of 2014 to 2018 (FracFocus 2019) to ascertain actual water use by the oil and gas industry in the San Juan Basin. This information is presented in Table 3-9.

Consumptive water use by municipal, industrial, and agricultural activities (including oil and gas activities) represents a single element of a hypothetical water budget for the planning area. While a detailed water budget quantifying hydrologic inputs and outputs for the planning area is outside the scope of this document, it should be noted that various hydrologic inputs are occurring alongside the consumptive water use depicted in Figure 2-4 and Figure 2-5. Groundwater can be recharged through a variety of processes such as precipitation, irrigation return flow, and seepage from rivers and streams. Similarly, groundwater discharge in the planning area occurs not only through consumptive water use, but also through evapotranspiration and discharge from springs and seeps.

Table 3-9. Actual Water Use in the San Juan Basin for Calendar Years 2014-2018

Year	Federal Water Use (AF)	Non-Federal Water Use (AF)	Total WU (AF)	Federal Water Use (%)	Federal Cumulative Water Use (AF)	Total Cumulative Water Use (AF)	Average Water Use per Well (AF)	Total # of Wells Reported to FracFocus
2014	165	155	320	51	165	320	2.4	133
2015	87	255	343	25	252	662	3.8	90
2016	86	26	111	77	337	773	2.5	44
2017	229	50	279	82	566	1,052	4.4	63
2018	361	282	643	56	927	1,695	4.6	141
Total	**927**	**768**	**1,695**	**--**	**--**	**--**	**--**	**471**

Source: FracFocus 2019.

Note: San Juan Basin is comprised of Sandoval, Rio Arriba, and San Juan Counties.

Water use by oil and gas wells in the San Juan Basin has increased from 320 AF in 2014 to 643 AF in 2018, with a corresponding basin-wide average water use per well increase from 2.4 AF per well to 4.6 AF per well (FracFocus 2019). Total federal cumulative water use in the basin was 927 AF during the same period, a percentage of 55 percent of total water use. Cumulative water use is calculated by adding all previous water use to the water use for any given year. The total number of wells that were reported to FracFocus from 2014 to 2018 also increased from 133 wells to 141 wells. As noted in Section 3.1.3, 20 wells have been drilled to date using long laterals with slick-water stimulation within the Farmington FO. The average lateral well bore was 1.5 miles in length and associated water use was approximately 41 AF.

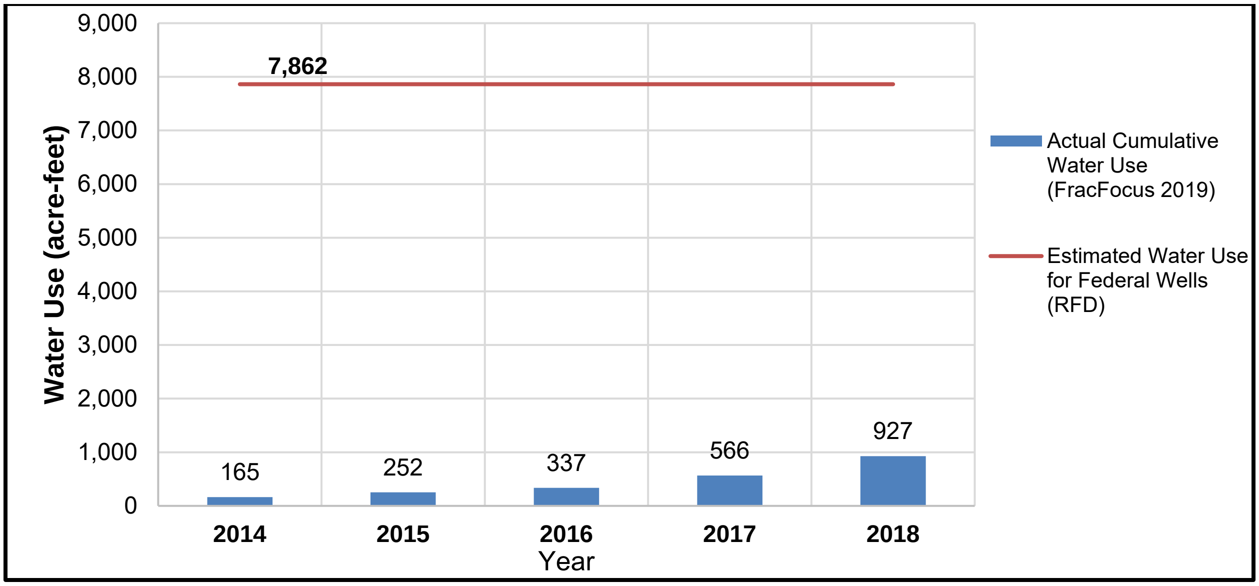
Reasonably Foreseeable Future Actions (RFFAs)

<u>Oil and Gas Development RFFAs</u>

As noted above in Section 3.1.2, Water Use Associated with Reasonably Foreseeable Oil and Gas Development, 3,200 wells are expected to be drilled in the planning area between 2018 and 2037, with a total of 1,980 wells being on federal land (1,580 horizontal and 400 vertical). Total water use for the RFD over the 20-year period is currently estimated at 11,615 AF, or about 580 AF in any given year. Well development projected as a result of ongoing BLM and state lease sales is already considered in the RFD. Well development associated with recent or reasonably foreseeable APDs or master development plans are also included in the RFD.

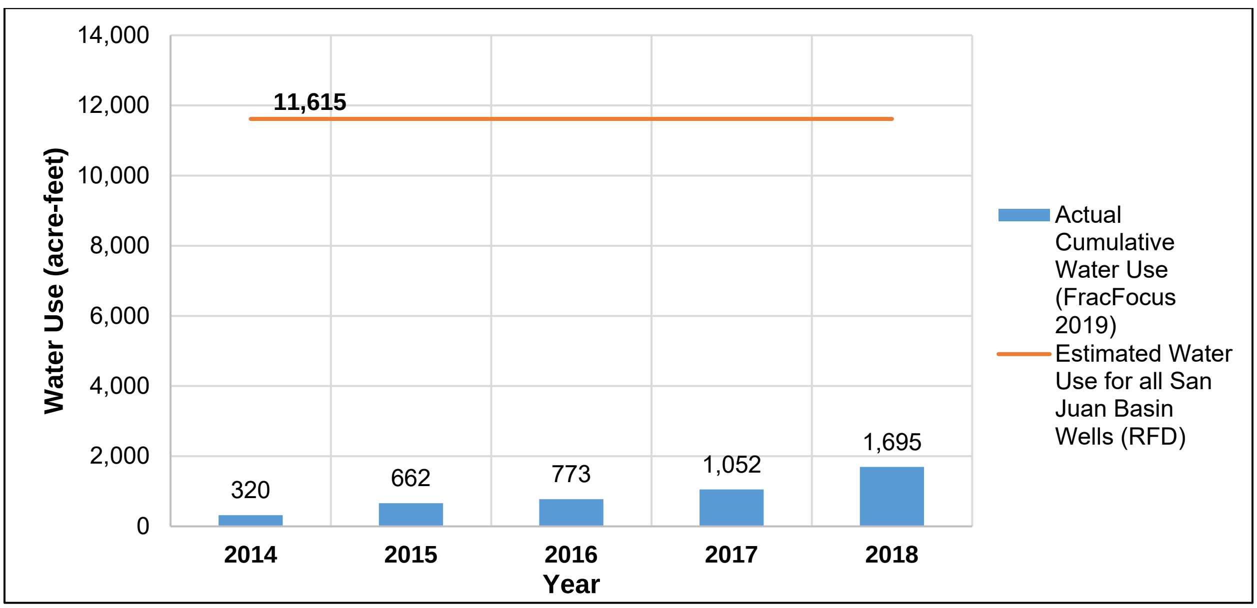
Figure 3.1 shows cumulative water use between 2014 and 2018 for federal wells in the San Juan Basin (FracFocus 2019) compared to water use estimates from the RFD scenario (Crocker and Glover 2018). A similar scenario is presented in Figure 3.2, which shows cumulative water use between 2014 and 2018 for all wells (both federal and non-federal) in the San Juan Basin (FracFocus 2019) compared to water use estimates from the RFD scenario (Crocker and Glover 2018). The total water use estimate for the RFD scenario is derived by assuming 2,300 wells would be drilled horizontally, and 900 wells would be drilled vertically.

For 2018 (the first year that is projected in the RFD), water use reported to Frac Focus was 643 AF. This is 5.5% of the total RFD water use estimate (11,615 AF), which is about 0.5 % (63 AF) higher than the RFD projection for any given year (580 AF).



Note: Actual water use from FracFocus 2019. Cumulative water use for each year (shown in blue) is calculated by adding the sum of all previous actual water use to the actual water use for any given year. The estimated water use for the federal wells in the San Juan Basin (shown in orange) is derived from the RFD scenario using the revised water use estimates discussed in Section 3.1.2 (4.84 AF per horizontal well). The RFD scenario estimates 1,980 federal wells (1,580 horizontal and 400 vertical).

Figure 3.1. Actual Water Use (2014-2018) Compared to Projected Water Use for Federal Wells in the San Juan Basin.



Note: Actual water use from FracFocus 2019. Cumulative water use for each year (shown in blue) is calculated by adding the sum of all previous actual water use to the actual water use for any given year. The estimated water use for all wells in the San Juan Basin (shown in orange) is derived from the RFD scenario using the revised water use estimates discussed in Section 3.1.2 (4.84 AF per horizontal well).

Figure 3.2 Actual Cumulative Use (2014-2018) Compared to Projected Water Use for All Wells in the San Juan Basin.

Beginning in 2015, the Farmington Field Office began receiving APDs that included new technologies that utilize greater quantities of water during the stimulation of the well under development. If operators implement the slickwater technology more frequently than occurred in 2018 and prior years, it is expected that total water use volumes on a per well basis will trend upward. To address this concern, the BLM analyzed data from FracFocus for 20 recent APDs utilizing slick water stimulation, and developed estimates of miles of lateral and associated water use for development of the RFD (2,300 horizontal wells over 20 years) using slick water stimulation techniques. Using an average of a 2-mile lateral (operator input gathered by the BLM suggests the horizontal lengths would range from 1-3 miles), the BLM estimates that development of 2,300 wells would result in 4,600 miles of laterals. The amount of water that would be required to completely develop 4,600 miles of horizontal wells in the Mancos Shale and Gallup Sandstone formations via slick water stimulation is estimated to be approximately 125,000 AF, or 6,250 AF in any given year (see Table 3-9 for water use factor by lateral length). This scenario was developed as a maximum reasonable estimate of future water use if existing slick water stimulation techniques (which currently comprise 3% of all well completions in the San Juan Basin) were to be applied to all 2,300 wells forecasted in the RFD over the next 20-years, versus the use of less water intensive stimulation technologies, such as nitrogen completions.

For 2018 (the first year that is projected in the RFD), water use reported to Frac Focus was 643 AF. This is 0.5% of the total slick water trend water use estimate (11,615 AF), which is about 4.5 % (5,607 AF) less than the slick water trend projection for any given year (6,250 AF).

Other (non-RFD) RFFAs

No other RFFAs with substantial use have been identified. Some water use would be required during construction and operation of reasonably foreseeable transmission lines and pipelines. These uses are minimal and are not quantified in this cumulative impact scenario analysis, but would be quantified at the site-specific EA level. Future water use for the other reported water use categories in the San Juan Basin is assumed to continue at current levels.

Cumulative Impacts

Development of the RFD using water use values of 0.537 AF/vertical well (Crocker and Glover 2018), and 4.84 AF/horizontal well (developed through a review 2018 FracFocus water use data) would result in the use of approximately 11,615 AF of water, or 580 AF of water in any given year (Table 3-11, column 1). This water use would occur over approximately 20 years and would cumulatively represent about 0.12 percent of San Juan Basin 2015 total water withdrawals (486,660 AF). As noted above, the agriculture would remain by far the largest water use within the San Juan Basin (currently 79 percent of all water use within the San Juan Basin).

If the slick water trends noted above are realized in the San Juan Basin and remain consistent over the 20- year development scenario timeframe, total cumulative water volumes would be closer to the totals disclosed in column 2 of Table 3-11 (approximately 125,000 AF, or 6,250 AF in any given year). This water use would occur over approximately 20 years and would cumulatively represent about 1.3 percent of San Juan Basin 2015 total water withdrawals (486,660 AF). As noted above, the agriculture would remain by far the largest water use within the San Juan Basin (currently 79 percent of all water use within the San Juan Basin).

Table 3-10. Cumulative RFD Water Use Volumes Based on 2019 Trend Projections

Well Orientation	2018 RFD	Slick Water Trend Projections	Quantity Increase
900 Vertical	483 AF	483 AF	0 AF
2,300 Horizontal	11,132 AF	124,515 AF	113,866 AF
Total 3200 Wells	**11,615AF**	**124,998 AF**	**113,866 AF**

Note: 2018 RFD water use is based on revised water use estimates (4.84 AF per horizontal well) documented above in Section 3.1.2. Updated Farmington FO 2019 Trend projection water use estimates are based on slick water fracturing planning factors (53 AF per 2 mile lateral) noted above and in Appendix C.

As noted in Section 3.1.3, slick water fracturing technology allows operators to utilize water with TDS of 50,000 ppm for use in slick water stimulation activities, which allows for the use of currently non-traditional water sources, including the connate water, recycled flowback water, and produced water (see Section 3.1.5). Appendix C contains additional background information on slick water fracturing in the Farmington FO as well as information regarding the methodology for capturing information and calculating water use by stage.

3.1.5. Potential Sources of Water for Project Development

Because most water used in mining activities in the counties that comprise the Farmington FO is currently from groundwater, it is reasonable to assume that a large portion of the water used for hydraulic fracturing under the RFD scenario would likely be groundwater. Groundwater is a more readily available source of water than surface water due to the ephemeral nature of many surface water features in the San Juan Basin. Generally, sources of groundwater can be found in nearly every area of the Farmington FO. Water yields in these areas vary, but most aquifers yield less than 20 gallons per minute (gpm) (BLM 2003). Aquifers that are known to yield sufficient quantities of water are usually found within the sandstone units of Jurassic, Cretaceous, and Tertiary age (BLM 2003). Aquifers that have the potential to yield 100 gpm include the Ojo Alamo Sandstone, the Nacimiento Formation, and the San Jose Formation, all of which are within the greater Unite-Animas aquifer (BLM 2003).

San Juan Basin oil and gas operators have included plans to use multiple hydraulic fracturing methods including slick water fracturing technology. The two general water types that may be used for slick water stimulation are categorized as “potable/fresh” and “non-potable”. Any water that has Total Dissolved Solids (TDS) greater than 1,000 ppm has been defined as “non-potable” by the State of New Mexico (72-12-25 NMSA 1978), the BLM has identified anything less than 10,000 ppm to be protected in the casing rule of the BLM’s Onshore Order #2 (BLM 1988). Non-potable water is outside the appropriative processes and is mainly diverted for mineral exploration purpose. The higher allowable TDS levels that are acceptable for slick water stimulation expand the possible water sources beyond those that are traditionally used (e.g., surface or ground water) into non-traditional sources of water (e.g. non-potable groundwater sources). Recently, the NMOSE has approved permits to drill wells within the San Juan Basin to withdraw non-potable connate water (groundwater) from the Entrada sandstone formation for use as a potential source of water for slick water stimulation operations (see Appendix C for more information). Water contained in the Entrada formation is highly saline (Kelley et al. 2014). As such, it is considered non-potable and has not been declared as an administrative aquifer by the NMOSE. Table 3-12 identifies four aquifers found within the Farmington FO, their associated rock types, and sources of recharge.

Table 3-11. Potential Sources of Groundwater in Farmington FO

Aquifer Name	Description	Sources of Recharge
Mesaverde	Sandstone, coal, siltstone and shale of the Mesaverde Group	Upland areas, mainly in areas of the Zuni Uplift, Chuska Mountains, and northern Sandoval County
Rio Grande	Unconsolidated sand and gravel basin-fill	Precipitation and snowmelt from the mountains and valleys that surround the basin. Most precipitation is lost to evaporation and transpiration, and very little percolates to a sufficient depth to recharge the aquifer.
Unite-Animas	Lower tertiary rocks; permeable, coarse, arkosic sandstone interlayered with mudstone; permeable conglomerate and medium to very coarse sandstone interlayered with relatively impermeable shale and mudstone	In higher elections that encircle the San Juan Basin
Entrada Sandstone	Sandstone; eolian sand dunes	Through surface exposures on the margins of the basin in the foothills of the Laramide uplifts.

Source: BLM 2003, Kelley et al 2014.

In order to further identify sources and quantity and quality of groundwater, the BLM is currently collaborating with Sandia National Laboratory on the development of a study that will identify counties that have high potential for oil and gas development within Farmington FO. The study will establish a water-level and chemistry baseline and develop a modeling tool to aid the BLM in understanding the regional water supply dynamics under different management, policy, and growth scenarios and to pre-emptively identify risks to water sustainability. Once this study is complete, this section will be updated to analyze and discuss the results.

Other sources of non-potable water that can be utilized in stimulation are “flowback fluid” and “produced water”. Flowback fluid is a mixture of water and small amounts of chemicals and other proppants that flow back through the well head directly after stimulation activities. Generally, 10-40% of the initial volume utilized for stimulation activities returns as flowback fluid, of this 10-40% is non-potable water that may be used in future stimulation activities. Produced water is naturally occurring water that exists in the formation that is being targeted for mineral extraction and is produced as a byproduct, therefore becoming “produced water”. Based on operator input, after the initial flowback recovery of 10-40%, remaining water used for stimulation does return to the surface through production activities at a slower rate of return.

Water used for oil and gas drilling and completion would generally be obtained through the following methods:

- leasing a valid water right through a State Engineer permit.
- buying/leasing water from a legal water provider (or, up to 3AF, a private well owner).
- purchasing water from a non-potable reclaimed water supplier.

It is speculative to predict the actual source of water that would be used for development of the RFD (or the development of any specific lease sales). In addition to utilizing surface or groundwater, operators may also bring water to a well site via truck from any number of sources. The transaction would be handled by the New Mexico Oil Conservation Division, as well as the New Mexico Office of the State Engineer. All water uses would be evaluated at the APD stage in site-specific NEPA analysis and subject to standard lease terms and conditions; however, it is important to note that sources of water for lease development are also not always known at the APD stage.

3.1.6. Water Use Mitigations

Overall, there have been calls to increase the use of alternative water sources such as brackish water or recycling produced water, minimizing the strain on local freshwater resources (Kondash et al. 2018). The BLM encourages the use of recycled water in hydraulic fracturing techniques. Moreover, recent studies indicate that the water used for hydraulic fracturing may be retained within the shale formation, with only a small fraction of the fresh water injected into the ground returning as flowback water; water returning to the surface is highly saline, difficult to treat, and is often disposed through deep-injection wells (Kondash et al. 2018). Thus, the ability to recycle water may be more limited than previously reported. Note that the water use calculations above do not assume the use of recycled water.

As noted above, water-intensive stimulation methods such as slick water fracturing can be accomplished using non-traditional water sources, including the connate water within the Entrada formation. NMOSE is the agency responsible for water withdrawal permitting actions. Their NOI process includes a model-based evaluation of the potential effects of proposed withdrawals and the identification of possible requirements for applicants to obtain water rights to offset any depletions identified in NMOSE's analyses prior to applicants commencing diversions.

3.2. Existing Water Quality

Sections 3.2.1 and 3.2.2 detail existing surface and ground water quality, and potential sources of surface and ground water contaminants associated with oil and gas development. In general, the analysis area for water sources for the Farmington FO is the San Juan Basin

3.2.1. Groundwater

Results of the hydrologic assessment of oil and gas development of the Mancos Shale in the San Juan Basin (Kelley et al. 2014) indicate that groundwater quality in the San Juan Basin is variable (ranging from fresh to brackish) due to the complex stratigraphy and varying rock formations within the Basin. Brackish and saline water is typically found in the center of the Basin, and fresh groundwater is typically found along the Basin margins. Deep saline water can migrate upward along cracks and fissures. Fresh water along the Basin margins at depths greater than 3,500 feet indicate fast recharge rates influenced by geologic structures (Kelley et al. 2014).

The geologic formation where groundwater resides also influences groundwater salinity. Figure 3.3 (Figure 15; Kelley et al. 2014) is an illustrated geologic cross section showing the distribution of saline aquifers within the San Juan Basin.

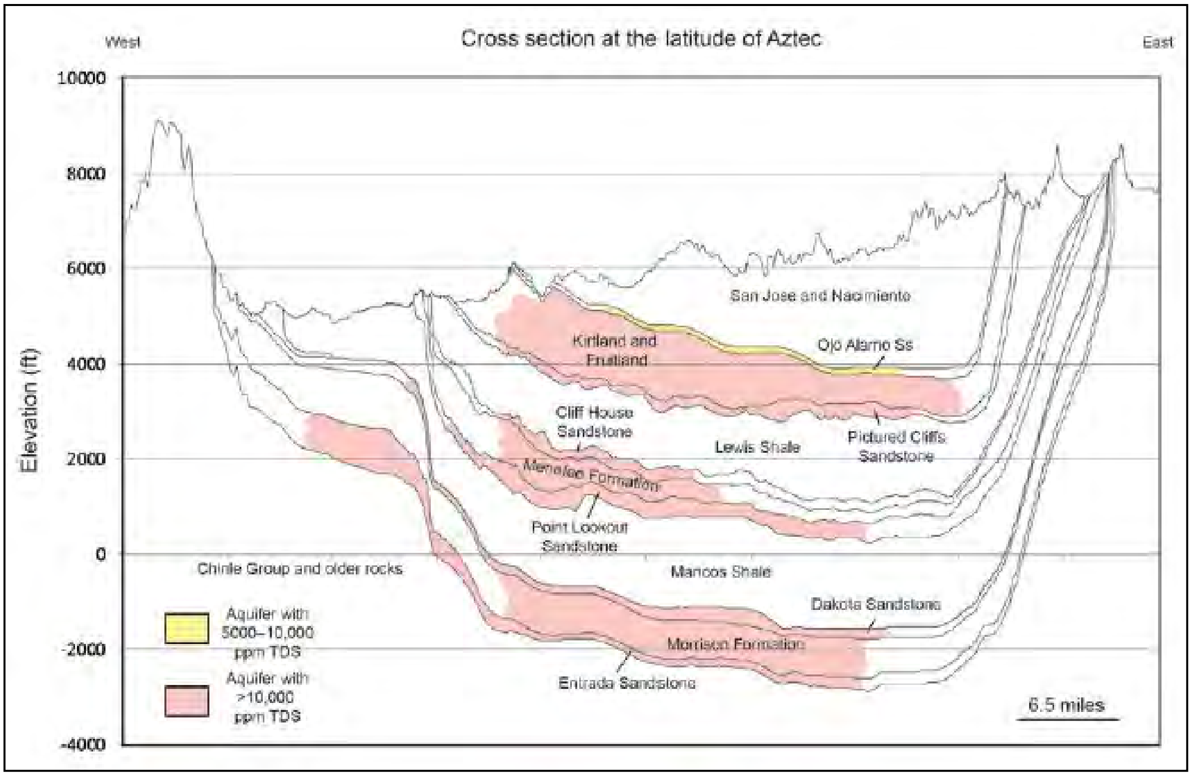


Figure 3.3. Geologic cross section showing the distribution of saline aquifers in the San Juan Basin.

Source: Figure 15 in Kelley et al. 2014.

Total dissolved solids (TDS) concentration is a measure of all the dissolved matter in a sample of water. TDS is the primary indicator of groundwater quality as higher TDS concentrations typically make water less suitable for drinking or for agricultural purposes like irrigation. In groundwater, TDS is influenced by the dissolution of natural materials such as rock, soil, and organic material. Anthropogenic activities also contribute to TDS concentrations in shallow unconfined aquifers.

TDS concentration in the San Juan Basin is dependent on the stratigraphic location and the geologic formation where the water resides. Fresh water (TDS < 1,000 milligrams per liter [mg/l]) is typically found at depths <2,500 feet (ft) below the ground surface, although exceptions to this generalization occur in deeper layers like the Gallup Sandstone and Morrison Formation. Saline and brackish water is dominant in the center of the Basin at deeper depths (Kelley et al. 2014).

As noted above in Section 3.1.2, the BLM is working with Sandia National Laboratory to prepare a report on water sustainability in the Farmington FO related to oil and gas development. Upon completion of that report, this section will be updated to discuss the results and further analyze groundwater quality.

3.2.2. Surface Water

Surface water quality streamflow data is limited to data gathered from perennial surface water drainages in the northern part of the Farmington FO planning area (BLM 2003) that are within various aquifers and watersheds. Surface water quality is dependent upon environmental related factors the water has encountered, such as upstream or downstream, types of rocks and soils, potential contaminants, and flow conditions. In general, surface water has relatively low concentrations of dissolved solids in its upper reaches, and high concentrations of magnesium, calcium, sodium, and sulfate in its middle and lower reaches; there are also higher concentrations of ions at low flow conditions (BLM 2003). To further asses surface water quality, data from the forthcoming Sandia National Laboratory report (as described above in Section 3.1.2) will be analyzed and discussed in this section once that report is available.

3.2.3. Potential Sources of Surface Water or Groundwater Contamination

Spills

Spills associated with oil and gas development may reach surface water directly during the spill event. Spills may also reach surface waters indirectly, when the spill has occurred and a rain event moves contaminants into nearby surface water bodies through surface water flow or even subsurface groundwater flow into springs that discharge into a surface water body.

The San Juan Basin has been a producing oil and natural gas field since the early to middle 1900s. According to available GIS data, approximately 37,000 wells have been drilled within the boundary of the Farmington FO (BLM 2018). In 2017 oil and gas development resulted in 5,979,536 barrels (bbls) of crude oil; 464,709,385 thousand cubic feet (mcf) of natural gas; and 17,068,297 bbls of produced water. As shown in Table 2-12, there were a total of 106 spills in the New Mexico portion of the San Juan Basin in 2018. The volume of spilled oil, natural gas, and produced water comprises approximately 2.0 percent, 0.0003 percent, and 0.01 percent, respectively, of 2017 oil, natural gas and produced water values. Appendix C contains a methodology for analyzing spill data.

The rate of recovery varied by spill type but, in general, about 55 percent of all spills were not recovered. Of the spills above, nine incidents were reported as having affected surface waterways: three incidents involving produced water (57 bbls, due to well equipment failure or pipeline corrosion), two incidents involving natural gas-methane (49 mcf, due to pipeline equipment failure or corrosion), one incident involving crude oil (8 bbls, due to tank or pit overflow), one incident involving condensate (3 bbls, due to flowline equipment failure), and two incidents involving other materials (240 bbls, during transport due to human error); NMOCD 2019). The BLM works with the NMOCD to remediate spills on public BLM lands. Per NMAC 19.15.29.11, the responsible person shall complete division-approved corrective action for releases that endanger public health or the environment in accordance with a remediation plan submitted to and approved by the division or with an abatement plan submitted in accordance with 19.15.30 NMAC. The remaining contaminates from unrecovered spills are remediated in accordance with federal and state standards. Some remediation consists of removing contaminated soil and replacing it with uncontaminated soil and corresponding chemical testing.

Table 3-12. Summary of 2018 Spills in San Juan Basin

Spilled Material Type	Number of Spills	Volume Spilled	Volume Lost	Units	% Volume Lost
Condensate	21	403	286	Barrels	71%
Crude Oil	12	1,174	273	Barrels	23%
Lube Oil	1	23	23	Barrels	100%
Motor Oil	1	0.07	0.07	Barrels	100%
Other (Specify)	12	605	412	Barrels	68%
Produced Water	34	873	402	Barrels	46%
Total	**81**	**3,078**	**1,396**	**Barrels**	**45%**
Natural Gas (Methane) and Natural Gas Liquids	25	117,325	112,502	MCF	96%
Total Number of Spills	**106**				

Source: NMOCD 2018.

Drilling and Completion Activities

The BLM and NMOCD's casing, cementing, and inspection requirements would limit the potential for groundwater reservoirs and shallow aquifers to be impacted by fracking or the migration of hydrocarbons on the nominated lease parcels. Prior to approving an APD, a BLM geologist would identify all potential subsurface formations that would be penetrated by the wellbore, including groundwater aquifers and any zones that would present potential safety or health risks that would need special protection measures during drilling, or that could require specific protective well construction measures. Casing programs and cement specifications would be submitted to the BLM and NMOCD for approval to ensure that well construction design would be adequate to protect the subsurface environment, including known or anticipated zones with potential risks or zones identified by the geologist. Surface casing would be set to an approved depth, and the well casing and cementing would stabilize the wellbore and provide protection to any overlying freshwater aquifers by isolating hydrocarbon zones from overlying freshwater aquifers. Before hydraulic fracturing takes place, all surface casings and intermediate zones would be required to be cemented from the bottom of the cased hole to the surface. The cemented well would be pressure tested to ensure there are no leaks, and a cement bond log would be run to confirm that the cement has bonded to the steel casing strings and to the surrounding formations.

The BLM requires operators to comply with the regulations at 43 CFR 3160. These regulations require oil and gas development to comply with directives in the Onshore Orders and the orders of the Authorized Officer. Onshore Order No. 2 and the regulations at 43 CFR 3162.3-3 provide regulatory requirements for hydraulic fracturing, including casing specifications, monitoring and recording, and management of recovered fluids. The State of New Mexico also has regulations for drilling, casing and cementing, completion, and plugging to protect freshwater zones (19.15.16 NMAC). Complying with the aforementioned regulations requires producers and regulators to verify the integrity of casing and cement jobs. Casing specifications are designed and submitted to the BLM together with an APD. The BLM petroleum engineer independently reviews the drilling plan and, based on site-specific geologic and hydrologic information, ensures that proper drilling, casing and cementing procedures are incorporated in the plan in order to protect usable groundwater. This isolates usable water zones from drilling, completion/hydraulic fracturing fluids, and fluids from other mineral bearing zones, including hydrocarbon bearing zones. Conditions of approval (COAs) are attached to the APD, if necessary, to ensure groundwater protection. Installation of the casing and cementing operations are witnessed by certified BLM Petroleum Engineering Technicians. At the end of the well's economic life, the operator must submit a plugging plan. The plugging plan ensures permanent isolation of usable groundwater from hydrocarbon bearing zones and is reviewed by the BLM petroleum engineer prior to well plugging. BLM inspectors ensure planned procedures are properly followed in the field.

Surface casing and cement would be extended beyond usable water zones. Production casing will be extended and adequately cemented within the surface casing to protect other mineral formations, in addition to usable water bearing zones. These requirements ensure that drilling fluids, hydraulic fracturing fluids, and produced water and hydrocarbons remain within the well bore and do not enter groundwater or any other formations. Since the advent of hydraulic fracturing, more than 1 million hydraulic fracturing treatments have been conducted, with perhaps only one documented case of direct groundwater pollution resulting from injection of hydraulic fracturing chemicals used for shale gas extraction (Gallegos and Varela 2015). Requirements of Onshore Order No. 2 (along with adherence to state regulations) make contamination of groundwater resources highly unlikely, and there have not been any documented past instances of groundwater contamination attributed to well drilling. This is an indication of how effective the use of casing and cement is at preventing leaks and contamination.

CHAPTER 4. RIO PUERCO FIELD OFFICE

The Rio Puerco Field Office (FO), located in central and western central New Mexico, is approximately 8,620,838 acres and includes all of Bernalillo, Cibola, Torrance, and Valencia Counties, most of Sandoval County, and small parts of McKinley and Santa Fe Counties (BLM 1986). Some of the land managed by the Rio Puerco FO is within the San Juan oil and gas basin, located in the four-corners area of the United States. To date, most of the drilling in the Rio Puerco FO has occurred in the portion of Sandoval County that is within the San Juan Basin.

Chapter 4 outlines existing and projected (reasonably foreseeable) water quantity and water quality for the Rio Puerco FO. The analysis is based on information gathered from the following sources: 1) the Reasonable Foreseeable Development Scenario for Oil and Gas Activities, Mancos-Gallup RMPA Planning Area, Farmington Field Office, northwestern New Mexico ("2018 RFD"; Crocker and Glover 2018), 2) 2015 consumptive water use data from a USGS report, Estimated Use of Water in the United States in 2015 (Dieter et. al. 2018), 3) FracFocus, a national hydraulic fracturing chemical registry managed by the Ground Water Protection Council and Interstate Oil and Gas Compact Commission (FracFocus 2018), and 4) hydrologic assessments from the New Mexico Bureau of Geology and Mineral Resources (Broadhead et al. 2018; Kelley et al. 2014).

4.1. Water Quantity

Section 4.1.1 documents the total 2015 water withdrawals for the seven counties that are within or partially within the Rio Puerco FO area boundary. Section 4.1.2 describes estimated water use associated with existing and projected (reasonably foreseeable) oil and gas activities within the Rio Puerco FO based on the e2018 RFD (Crocker and Glover 2018). This RFD scenario was originally developed for the Farmington FO, but the BLM has extended its applicability to the Rio Puerco FO because the same geologic formations are present in both Field Offices. The analysis area for examining reasonably foreseeable impacts to water quantity is restricted to the New Mexico portion of the San Juan Basin where most of the oil and gas development is expected to take place. However, existing water use data (Dieter et al. 2018) is provided for the seven counties that are within or partially within the Rio Puerco FO for use in future water quantity analysis.

4.1.1. Existing Surface and Groundwater Use

Rio Puerco FO (Sandoval, Bernalillo, McKinley, Torrance, Santa Fe, Cibola, and Valencia Counties)

Total 2015 consumptive water use data for the seven counties that intersect the Rio Puerco FO are summarized in Table 4-1 through Table 4-7.Water use data is provided for the eight categories within each county: public water supply, industrial, irrigation, livestock, aquaculture, mining (including oil and gas), thermoelectric power, and domestic. For each category, water use totals (in acre-feet per year [AF/yr]) are summarized for surface and groundwater. Surface and groundwater totals are further divided to show the amount of fresh water and saline water used for each category. The USGS data (Dieter et al. 2018) show that no surface water was used in any of the seven counties that comprise the Rio Puerco FO planning area in 2015.

In Sandoval County, where most of the drilling in the Rio Puerco FO is expected to take place, mining accounts for 2 percent (1,312 AF/yr) of the total water use in the county. All water used by mining activities in Sandoval County comes from groundwater. The largest water use categories in Sandoval County are irrigation (79percent), followed by public water supply (8 percent). Most drilling activities in the Rio Puerco FO are expected to take place in the northwest corner of Sandoval County which falls within the San Juan Basin where there is a much greater development potential for oil and gas than in other areas of the county. This determination is based on a 2018 report submitted to the Sandoval County Planning and Zone Commission about the oil and natural gas potential of Sandoval County, which included a discussion on the potential for aquifer contamination (Broadhead et al. 2018). According to this report, the oil and gas development in Sandoval County has thus far occurred in the northern part of the county that is within the San Juan Basin. This trend is likely to continue because "oil and gas potential decreases southward primarily because petroleum source rocks, including the Mancos Shale, become less mature in this direction" (Broadhead et al. 2018:8).

In Bernalillo County, consumptive water use from mining activities in 2015 was 135 AF/yr, which was less than 1 percent of the total water use in that county. The major water use category in Bernalillo County is public water supply, which accounts for 69 percent of the total water use in that county.

Consumptive water use from mining activities in McKinley County accounts for 17 percent of the total water use (Dieter et al. 2018). The 2015 USGS data show water use by county and not BLM field office boundary; therefore, it is not known if mining activities accounting for 17 percent of the total water use are within the Rio Puerco FO or within the neighboring Farmington FO.

In Valencia County, consumptive water use from mining activities in 2015 was 437 AF/yr (all from groundwater), which was less than 1 percent of the total water use in that county. In 2015, irrigation withdrawals accounted for 93 percent of the total water use.

Torrance County water use data is similar to Valencia County. Mining activities used 112.1 AF of water in 2015 (all from groundwater). Water used for mining accounted for 0.2 percent of the total 2015 water use. The dominant water use category in Torrance County was irrigation, which accounted for 94 percent of the total water withdrawal.

In Santa Fe County, located in the northeastern portion of the Rio Puerco FO, consumptive water use from mining activities accounted for 0.6 percent of the total 2015 water use. The largest water use category in Santa Fe County was irrigation at 62 percent, followed by public water supply (30 percent).

Consumptive water used in mining activities in Cibola County account for 13 percent of the 2015 total water use. Most of the groundwater used was saline.

San Juan Basin (Sandoval, Rio Arriba, McKinley, and San Juan Counties)

Table 4-8 summarizes the 2015 water withdrawals within the New Mexico portion of the San Juan Basin, which is comprised of Sandoval, Rio Arriba, McKinley, and San Juan Counties, because the New Mexico portion of the San Juan Basin presents the highest potential for oil and gas development in the Rio Puerco FO. The 2018 RFD scenario states that "unless significant new oil and gas discoveries are made in the area, future activity will be primarily horizontal drilling for oil in the Mancos-Gallup play, with minor development targeted at natural gas production" (Crocker and Glover 2018:4). In 2015 water withdrawals for the mining category accounted for 2 percent of the total water use in the New Mexico portion of the San Juan Basin. Most of the mining water was saline groundwater.

State of New Mexico Water Use

In 2015, withdrawals for all water use categories across the State of New Mexico totaled 3,249,666.9 AF (Dieter et al. 2018). Table 4-9 lists the water withdrawals for the major industries in New Mexico. As shown in the table, *Mining* water withdrawals totaled 163,901 AF, or about 5 percent of the total water withdrawals for the State of New Mexico. While the data presented in this table are for the state as a whole, most water use in this category is from the Permian Basin, with some water use from the New Mexico portion of the San Juan Basin.

Table 4-1. 2015 Sandoval County Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% of Total Water**
Aquaculture	0	0	0	0%	1,087	0	1,087	100%	1,087	0	1,087	1%
Domestic	0	0	0	0%	3,128	0	3,128	100%	3,128	0	3,128	2%
Industrial	0	0	0	0%	2,578	0	2,578	100%	2,578	0	2,578	1%
Irrigation	48,326	0	48,326	99%	2,3201	0	2,321	1%	50,647	0	50,647	79%
Livestock	101	0	101	31%	123	0	123	69%	224	0	224	0%
Mining	0	0	0	23%	1,065	247	1,312	77%	1,065	246.6	1,312	2%
Public Water Supply	135	0	135	55%	12,466	0	12,466	45%	12,600	0	12,600	8%
Thermoelectric power	0	0	0	93%	0	0	0	7%	0	0	0	7%
County Totals	**48,562**	**0**	**48,562**	**90%**	**22,768**	**247**	**23,014**	**10%**	**71,329**	**246.6**	**71,576**	**100%**

Source: Dieter et al. 2018

Table 4-2. 2015 Bernalillo County Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% of Total Water**
Aquaculture	0	0	0	0%	22	0	22	100%	22	0	22	0%
Domestic	0	0	0	0%	1,312	0	1,312	100%	1,312	0	1,317	1%
Industrial	0	0	0	0%	56	0	56	100%	56	0	56	0%
Irrigation	38,843	0	38,843	83%	7,701	0	7,701	17%	46,544	0	46,544	30%
Livestock	11	0	11	6%	191	0	191	094%	202	0	202	0%
Mining	0	0	0	0%	135	0	135	100%	135	0	135	0%
Public Water Supply	52,743	0	52,743	49%	54,077	0	54,077	50%	106,820	0	106,820	69%
Thermoelectric power	0	0	0	0%	292	0	292	100%	292	0	292	0%
County Totals	**91,597**	**0**	**91,597**	**59%**	**63,785**	**0**	**63,785**	**41%**	**155,382**	**0**	**155,3819**	**100%**

Source: Dieter et al. 2018

Table 4-3. 2015 McKinley County Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	Fresh	Saline	Total Surface Water	% of Total Water	Fresh	Saline	Total Groundwater	% of Total Water	Total Fresh Water	Total Saline Water	Total Water	% of Total Water
Aquaculture	0	0	0	0%	0	0	0	0%	0	0	0	0%
Domestic	0	0	0	0%	3,195	0	3,195	100%	3,195	0	3,195	24%
Industrial	0	0	0	0%	34	0	34	100%	34	0	34	0%
Irrigation	1,099	0	1,099	100%	0	0	0	0%	1,099	0	1,099	8%
Livestock	101	0	101	21%	370	0	370	79%	471	0	471	4%
Mining	0	0	0	0%	1,626	684	2,309	100%	1,626	684	2,309	17%
Public Water Supply	0	0	0	0%	3,811	0	3,811	100%	3,811	0	3,811	29%
Thermoelectric power	0	0	0	0%	2,298	0	2,298	100%	2,298	0	2,298	17%
County Totals	**1,200**	**0**	**1,200**	**9%**	**11,333**	**684**	**12,017**	**91%**	**12,533**	**684**	**13,217**	**100%**

Source: Dieter et al. 2018

Table 4-4. 2015 Valencia County Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	Fresh	Saline	Total Surface Water	% of Total Water	Fresh	Saline	Total Groundwater	% of Total Water	Total Fresh Water	Total Saline Water	Total Water	% of Total Water
Aquaculture	0	0	0	0%	0	0	0	0%	0	0	0	0%
Domestic	0	0	0	0%	3,554	0	3,554	100%	3,554	0	3,554	2%
Industrial	0	0	0	0%	0	0	0	0%	0	0	0	0%
Irrigation	136,157	0	136,157	93%	10,089	0	10,089	7%	146,246	0	146,246	93%
Livestock	34	0	34	3%	987	0	987	97%	1,020	0	1,020	1%
Mining	0	0	0	0%	437	0	437	100%	437	0	437	0%
Public Water Supply	0	0	0	0%	5,538	0	5,538	100%	5,538	0	5,538	4%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0	0	0%
County Totals	**136,190**	**0**	**136,190**	**867%**	**20,604**	**0**	**20,604**	**13%**	**156,794**	**0**	**156,794**	**100%**

Source: Dieter et al. 2018

Table 4-5. 2015 Torrance County Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% of Total Water**
Aquaculture	0	0	0	0%	0	0	0	0%	0	0	0	0%
Domestic	0	0	0	0%	437	0	437	100%	437	0	437	1%
Industrial	0	0	0	0%	0	0	0	0%	0	0	0	0%
Irrigation	0	0	0	0%	45,849	0	45,849	100%	45,849	0	45,849	94%
Livestock	45	0	45	7%	605	0	605	93%	650	0	650	1%
Mining	0	0	0	0%	112	0	112	100%	112	0	112	0%
Public Water Supply	0	0	0	0%	1,973	0	1,973	100%	1,973	0	1,973	4%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0	0	0%
County Totals	**45**	**0**	**45**	**0.1%**	**48,977**	**0**	**48,977**	**100%**	**49,021**	**0**	**49,021**	**100%**

Source: Dieter et al. 2018

Table 4-6. 2015 Santa Fe County Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% of Total Water**
Aquaculture	0	0	0	0%	0	0	0	0%	0	0	0	0%
Domestic	0	0	0	0%	2,522	0	2,522	100%	2,522	0	2,522	6%
Industrial	0	0	0	0%	0	0	0	0%	0	0	0	0%
Irrigation	11,378	0	11,378	47%	12,936	0	12,936	53%	24,315	0	24,315	62%
Livestock	56	0	56	45%	67	0	67	55%	123	0	123	0%
Mining	0	0	0	0%	224	0	224	100%	224	0	224	1%
Public Water Supply	4,663	0	4,663	39%	7,185	0	7,186	60%	11,849	0	11,849	30%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0	0	0%
County Totals	**16,098**	**0**	**16,098**	**41%**	**22,936**	**0**	**22,936**	**59%**	**39,033**	**0**	**39,033**	**100%**

Source: Dieter et al. 2018

Table 4-7. 2015 Cibola County Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% of Total Water**
Public Water Supply	0	0	0	0%	2,668.0	0	2,668.0	100%	2,668	0	2,668	25%
Industrial	0	0	0	0%	0	0	0	0%	0	0	0	0%
Irrigation	1,5912	0	1,592	29%	3,856.2	0	3,856.2	71%	5,448	0	5,448	50%
Livestock	34	0	34	20%	134.5	0	134.5	80%	168	0	168	2%
Aquaculture	0	0	0	0%	0	0	0	0%	0	0	0	0%
Mining	0	0	0	0%	67.3	1,356.4	1,423.7	100%	67	1,356	1,424	13%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0	0	0%
Domestic	0	0	0	0%	1,143.4	0	1,143.4	100%	1,143	0	1,143	11%
County Totals	**1,626**	**0**	**1,626**	**15%**	**7,869.4**	**1,356.4**	**9,225.8**	**85%**	**9,495**	**1,356**	**10,851**	**100%**

Source: Dieter et al. 2018

Table 4-8. 2015 San Juan Basin Water Use by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% Total Water**
Public Water Supply	21,612.9	0.0	21,612.9	4%	17,958.4	0.0	17,958.4	4%	39,571.3	0.0	39,571.3	8%
Industrial	0.0	0.0	0.0	0%	2,634.4	0.0	2,634.4	1%	2,634.4	0.0	2,634.4	1%
Irrigation	381,240.9	0.0	381,240.9	78%	3,576.0	0.0	3,576.0	1%	384,816.9	0.0	384,816.9	79%
Livestock	437.2	0.0	437.2	0%	986.5	0.0	986.5	0%	1,423.7	0.0	1,423.7	0%
Aquaculture	0.0	0.0	0.0	0%	4,640.9	0.0	4,640.9	1%	4,640.9	0.0	4,640.9	1%
Mining	2,724.0	0.0	2,724.0	0.6%	3,676.9	5,257.5	8,934.4	1.8%	6,400.9	5,257.5	11,658.4	2%
Thermoelectric power	30,636.9	0.0	30,636.9	6%	2,298.1	0.0	2,298.1	0%	32,935.0	0.0	32,935.0	7%
Domestic	0.0	0.0	0.0	0%	8,979.2	0.0	8,979.2	2%	8,979.2	0.0	8,979.2	2%
County Totals	436,651.9	0.0	436,651.9	89.7%	44,750.3	5,257.5	50,007.8	10.3%	481,402.2	5,257.5	486,659.7	100%

Table 4-9. 2015 Statewide Water Use in New Mexico by Category (AF)

	Surface Water				Groundwater				Total Water			
Category	**Fresh**	**Saline**	**Total Surface Water**	**% of Total Water**	**Fresh**	**Saline**	**Total Groundwater**	**% of Total Water**	**Total Fresh Water**	**Total Saline Water**	**Total Water**	**% of Total Water**
Public Water Supply	87,751.9	0	87,751.9	3%	205,714.7	0	205,714.7	6%	293,466.6	0	293,466.6	9%
Industrial	0	0	0	0%	3,811.4	0	3,811.4	0%	3,811.4	0	3,811.4	0%
Irrigation	1,485,112.0	0	1,485,112.0	46%	1,175,312.5	0	1,175,312.5	36%	2,660,424.5	0	2,660,424.5	82%
Livestock	2,522.3	0	2,522.3	0%	33,372.2	0	33,372.2	1%	35,894.4	0	35,894.4	1%
Aquaculture	6,109.5	0	6,109.5	0%	20,929.1	0	20,929.1	1%	27,038.5	0	27,038.5	1%
Mining	19,550.2†	0	19,550.2	1%	44,111.4	100,239.8	144,351.2	4%	63,661.6	100,239.8	163,901.4	5%
Thermoelectric power	30,636.9	0	30,636.9	1%	6,871.7	0	6,871.7	0%	37,508.7	0	37,508.7	1%
Domestic	0	0	0	0%	27,621.4	0	27,621.4	1%	27,621.4	0	27,621.4	1%
Totals	**1,631,682.8**	**0**	**1,631,682.8**	**50.2%**	**1,517,744.3**	**100,239.8**	**1,617,984.1**	**49.8%**	**3,149,427.1**	**100,239.8**	**3,249,666.9**	**100%**

Source: Source: Dieter et al. 2018; updated with additional information provided to the BLM from the NMOSE regarding water use of the Navajo Power Plant (BLM 2019a).

† Approximately 19,550 AF of the freshwater use within the Mining industry is from surface water; the remainder of all other water use is from groundwater. The Mining category includes the following self-supplied enterprises that extract minerals occurring naturally in the earth's crust: solids, such as potash, coal, and smelting ores; liquids, such as crude petroleum; and gases, such as natural gas. This category includes water used for oil and gas production (well drilling and secondary recovery of oil), quarrying, milling (crushing, screening, washing, flotation, etc.), and other processing done at the mine site or as part of a mining activity, as well as water removed from underground excavations (mine dewatering) and stored in—and evaporated from—tailings ponds. The Mining category also includes water used to irrigate new vegetative covers at former mine sites that have been reclaimed. It does not include the processing of raw materials, such as smelting ores, unless this activity occurs as an integral part of a mining operation and is included in an NMOSE permit.

4.1.2. Water Use Associated with Reasonably Foreseeable Oil and Gas Development

Estimates for the number of oil and gas wells that could reasonably occur in the San Juan Basin were derived from two RFD scenarios: Reasonable Foreseeable Development Scenario (RFD) for Fluid Mineral Development in the Rio Puerco Field Office (BLM 2010) and the 2018 RFD (Crocker and Glover 2018).

The BLM 2010 RFD forecasted development of approximately 5.5 wells per year in the Rio Puerco FO, of which three were anticipated to be in the San Juan Basin. The 2018 RFD (Crocker and Glover 2018) Scenario projected 3,200 wells to be drilled in the Mancos-Gallup planning area between 2018 and 2037. Of the 3,200 wells projected to be drilled between 2018 and 2037, 2,300 are expected to be horizontal and 900 are expected to be vertical.

The 2018 RFD (Crocker and Glover 2018) was used to forecast the potential quantity of oil and gas wells in the Mancos-Gallup Resource Management Plan Amendment (RMPA) Planning Area. The RFD was also used to forecast estimates the quantity of water that would be required for hydraulic fracturing of the forecasted wells. These water use estimates assume that 100% of wells will be hydraulically fractured, and do not account for re-use or recycling of hydraulic fracturing fluid. While the 2018 RFD was originally developed for the Farmington FO, it is applicable to the Rio Puerco FO because the Mancos-Gallup planning area examined in the 2018 RFD included the portion of the Rio Puerco office where oil and gas development has typically occurred and because the same geologic formations that underlie the Farmington FO also underlie parts of the Rio Puerco FO likely to be developed in the future. The 2018 RFD incorporates more recent data than the 2010 RFD and discusses surface disturbance associated with both horizontal and vertical development. As such, the 2018 RFD is a reasonable estimate of the development and consumptive water use associated with hydrocarbon production in the New Mexico portion of the San Juan Basin for the next 20 years (2018–2037).

Water use associated with hydraulic fracturing is dependent on many factors, including the drilling method (horizontal or vertical) and the geologic formation at the well site. The 2018 RFD scenario utilizes water use estimates from a 2014 RFD scenario from the New Mexico Bureau of Geology and Mineral Resources entitled *Hydrologic Assessment of Oil and Gas Resource Development of the Mancos Shale in the San Juan Basin* by Kelley et al. (2014). According to Kelley et al. (2014:4), "vertical wells drilled into the Mesaverde Group, Gallup Sandstone, and the Dakota Sandstone account for 83% of the hydraulically fractured completions [in the San Juan Basin] since 2005."

Water use per well is dependent on the geologic formation, but on average, the water use for vertical wells in the New Mexico portion of the San Juan Basin is 0.537 AF/well (Crocker and Glover 2018). Horizontal wells require more water than vertical wells. The 2018 RFD reported that horizontal wells in the New Mexico portion of the San Juan Basin require on average approximately 3.13 AF of water. More recent information on horizontal well development in the New Mexico portion of the San Juan Basin has indicated water use is higher. Because of this uncertainty, the BLM conducted studies using calendar year 2018 data from FracFocus, a national hydraulic fracturing chemical registry managed by the Ground Water Protection Council and Interstate Oil and Gas Compact Commission, to provide objective information on hydraulic fracturing. Operators are required by the State of New Mexico to disclose chemistry and water use information on FracFocus. Analysis of the FracFocus data for the New Mexico portion of the San Juan Basin (which included 126 records) resulted in a value of 4.8 AF of water per horizontal well. As a result of these studies, the BLM considers the estimate of 4.8 AF the most accurate current estimate of water use per horizontal well in the New Mexico portion of the San Juan Basin. Table 4-10 provides a comparison of the water use estimates used in the RFD and the BLM's revised water use estimates. Some factors have been modified based on best available information (for example, the projected water use associated with horizontal drilling methods discussed above) as well as best professional judgment of BLM engineering staff and resource specialists.

Table 4-10. Projected Water Use in San Juan Basin (Farmington FO and Rio Puerco FO)

Factor	Water Use in RFD (Crocker and Glover 2018)	Revised Water Use	Rationale for Change
Average Water Use per Horizontal Well during a hydraulic fracturing operation	3.13 AF	4.8 AF[1]	Reflects actual use as reported in FracFocus
Average Water Use per Vertical Well during a hydraulic fracturing operation	0.48 AF	0.537 AF[2]	NA
Total Water Use (2018-2037)	7,683 AF[3]	11,523 AF[3]	

[1] Source: FracFocus 2018

[2] Source: Crocker and Glover 2018. Estimated water use based on number of wells in each geologic formation.

[3] Total water use = (2,300 horizontal wells * horizontal well water use estimate) + (900 vertical wells * vertical well water use estimate)

Note: AF is acre-feet.

Water used for development of the estimated 3,200 wells in the RFD scenario (Crocker and Glover 2018) is assumed to come primarily from groundwater sources based on previous oil and gas development in the area and from county water use data summarized above in Tables 4-1 through 4-8 (Dieter et al. 2018). Drilling and completion of the 3,200 wells estimated to occur in the planning area would require approximately 7,683 AF using water use estimates contained in the Crocker and Glover RFD scenario, and 11,615 AF of water using the BLM's revised water use estimates (1.6 and 2.4 percent, respectively, of the 2015 total water withdrawal in the San Juan Basin, if the entire RFD were to be developed in one year).

The cumulative impact on water use in the San Juan Basin for any given year during the 20-year RFD scenario is estimated by assuming wells and corresponding water use would be developed at a constant rate over a 20-year period (RFD scenario). Using the Crocker and Glover RFD scenario, water use for development of oil and gas would be 7,683 AF, or 384 AF for any given year in the 20-year period of the RFD, which is approximately 0.08 percent of the total 2015 water withdrawals in the San Juan Basin.

Using the BLM's revised water use figures, water use for development of oil and gas for any given year in the 20-year period of the RFD would be about 580 AF, which is approximately 0.12 percent of the total 2015 water withdrawals in the San Juan Basin. If all wells in the RFD were developed in one year, the water use required (11,615 AF) would be approximately 2.4 percent of the total 2015 water use in the San Juan Basin (486,660 AF).

Water use could increase if more water-intensive stimulation methods (e.g., slick water fracturing) are implemented or if laterals become longer. Alternatively, water use estimates could be lower if produced water is reused or recycled for use in hydraulic fracturing.

4.1.3. Cumulative Water Use Estimates

Past and Present Actions

Past and present use is discussed in Section 4.1.1, Existing Surface and Groundwater Use. As noted in that section, total water use in the counties comprising the San Juan Basin (486,660 AF) accounted for 15 percent of total state withdrawals (3,249,667 AF) in 2015 (Dieter et al. 2018). Mining (which includes oil and gas development) comprised about 2 percent of San Juan Basin total water withdrawals. The largest user of water in the San Juan Basin is irrigation (comprising 79 percent of all withdrawals in the San Juan Basin).

The BLM also examined FracFocus data reported for the calendar years of 2014 to 2018 (FracFocus 2019) to ascertain actual water use by the oil and gas industry in the San Juan Basin. This information is presented in Table 4-11.

Consumptive water use by municipal, industrial, and agricultural activities (including oil and gas activities) represents a single element of a hypothetical water budget for the planning area. While a detailed water budget quantifying hydrologic inputs and outputs for the planning area is outside the scope of this document, it should be noted that various hydrologic inputs are occurring alongside the consumptive water use depicted in Figures 2-4 and Figures 2-5. Groundwater can be recharged through a variety of processes such as precipitation, irrigation return flow, and seepage from rivers and streams. Similarly, groundwater discharge in the planning area occurs not only through consumptive water use, but also through evapotranspiration and discharge from springs and seeps.

Table 4-11. Actual Water Use in the San Juan Basin for Calendar Years 2014-2018

Year	Federal Water Use (AF)	Non-Federal Water Use (AF)	Total WU (AF)	Federal Water Use (%)	Federal Cumulative Water Use (AF)	Total Cumulative Water Use (AF)	Average Water Use per Well (AF)	Total # of Wells Reported to FracFocus
2014	165	155	320	51	165	320	2.4	133
2015	87	255	343	25	252	662	3.8	90
2016	86	26	111	77	337	773	2.5	44
2017	229	50	279	82	566	1,052	4.4	63
2018	361	282	643	56	927	1,695	4.6	141
Total	**927**	**768**	**1,695**	**--**	**--**	**--**	**--**	**471**

Source: FracFocus 2019.

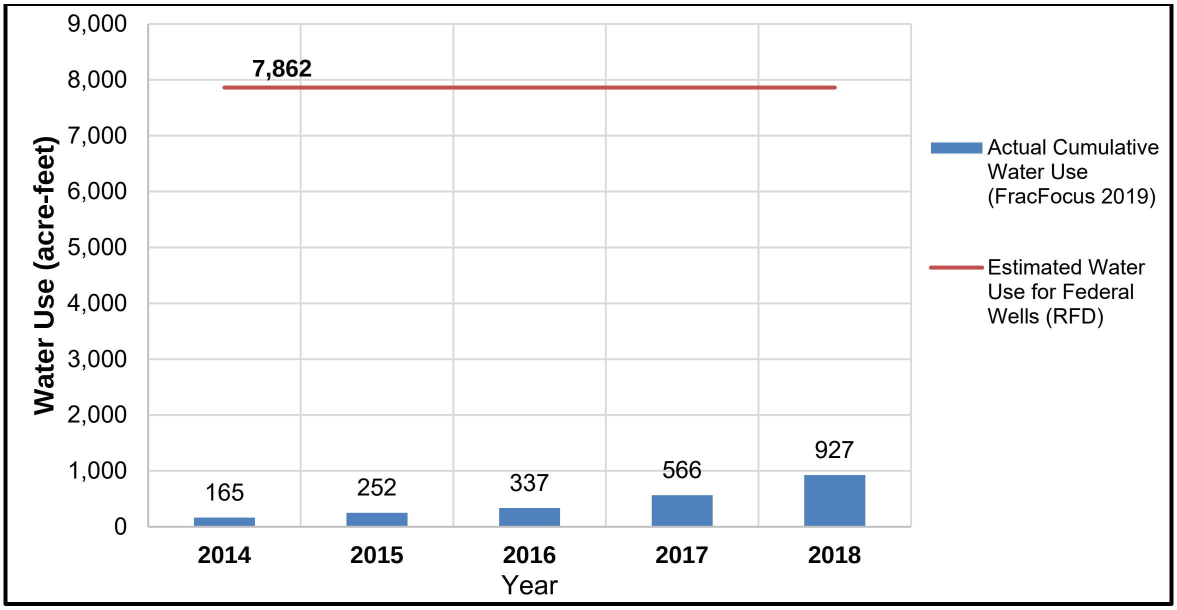
Note: San Juan Basin is comprised of Sandoval, Rio Arriba, and San Juan Counties.

Water use by oil and gas wells in the San Juan Basin has increased from 320 AF in 2014 to 643 AF in 2018, with a corresponding basin-wide average water use per well increase from 2.4 AF per well to 4.6 AF per well (FracFocus 2019). Total federal cumulative water use in the basin was 927 AF during the same period, a percentage of 55 percent of total water use. Cumulative water use is calculated by adding all previous water use to the water use for any given year. The total number of wells that were reported to FracFocus from 2014 to 2018 also increased from 133 wells to 141 wells.

Oil and Gas Development RFFAs

RFD

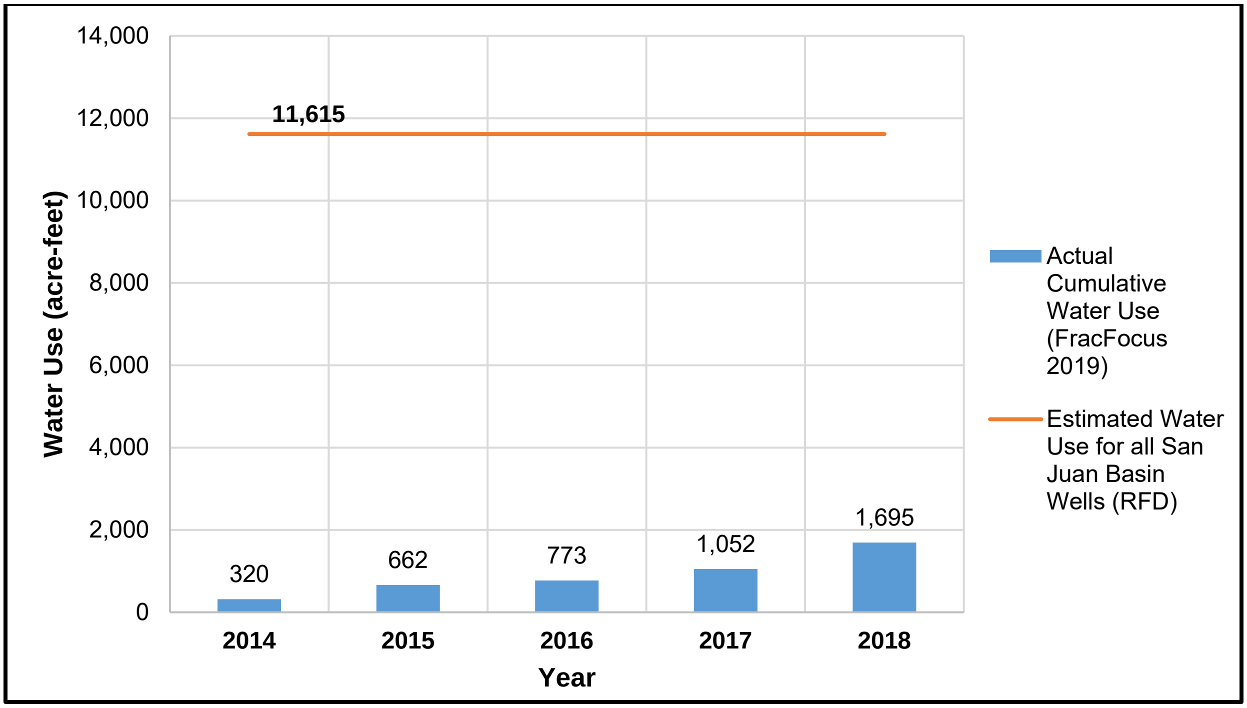
As noted in Section 4.1.2, Water Use Associated with Reasonably Foreseeable Oil and Gas Development, 3,200 wells are expected to be drilled in the San Juan Basin between 2018 and 2037, with a total of 1,980 wells on federal land (1,580 horizontal and 400 vertical). Total water use for the RFD over the 20-year period is currently estimated at 11,615 AF, or about 580 AF in any given year. Well development projected as a result of ongoing BLM and state lease sales is already considered in these RFDs. Well development associated with recent or reasonably foreseeable APDs or master development plans are also included in these RFDs. Figure 4-1 shows cumulative water use between 2014 and 2018 for federal wells in the San Juan Basin (FracFocus 2019) compared to water use estimates from the RFD scenario (Crocker and Glover 2018).



Note: Actual water use from FracFocus 2019. Cumulative water use for each year (shown in blue) is calculated by adding the sum of all previous actual water use to the actual water use for any given year. The estimated water use for federal wells in the San Juan Basin (shown in orange) is derived from the RFD scenario using the revised water use estimates discussed in Section 3.1.2 (4.84 AF per horizontal well). The RFD scenario estimates 1,980 federal wells (1,580 horizontal and 400 vertical).

Figure 4.1. Actual Water Use (2014-2018) Compared to Projected Water Use for Federal Wells in the San Juan Basin.

A similar scenario is presented in Figure 4-2, which shows cumulative water use between 2014 and 2018 for all wells (both federal and non-federal) in the San Juan Basin (FracFocus 2019) compared to water use estimates from the RFD scenario (Crocker and Glover 2018). As noted in Section 4.1.2, Water Use Associated with Reasonably Foreseeable Oil and Gas Development, 3,200 wells are expected to be drilled in the planning area between 2018 and 2037. Total consumptive water use for the RFD over the 20-year period is currently estimated at 11,615 AF, or about 580 AF in any given year.



Note: Actual water use from FracFocus 2019. Cumulative water use for each year (shown in blue) is calculated by adding the sum of all previous actual water use to the actual water use for any given year. The estimated water use for all wells in the San Juan Basin (shown in orange) is derived from the RFD scenario using the revised water use estimates discussed in Section 3.1.2 (4.84 AF per horizontal well).

Figure 4.2. Actual Cumulative Use (2014-2018) Compared to Projected Water Use for All Wells in the San Juan Basin.

2019 Oil and Gas Trends

In 2018, the Rio Puerco FO did not receive any APDs. The cumulative analysis herein is for the San Juan Basin as a whole and all APD authorizations noted for 2018 were processed through the Farmington FO. In 2019, by the publication date of this report, the Rio Puerco FO has received two APDs for wells located on Zia trust lands, with federal minerals. The two wells are vertical, and the water usage is expected to be consistent with that projected in the RFD for vertical wells.

Other RFFAs

No other RFFAs with substantial use have been identified. Some water use would be required during construction and operation of reasonably foreseeable transmission lines and pipelines; however, these uses are minimal and are not quantified in this analysis. Future water use for the other reported water use categories in the San Juan Basin is assumed to continue at current levels.

Cumulative Impacts

Development of the RFD using water use values of 0.537 AF/vertical well (Crocker and Glover 2018), and 4.84 AF/horizontal well (developed through a review 2018 FracFocus water use data) would result in the use of approximately 11,615 AF of water, or 580 AF of water in any given year. This water use would occur over approximately 20 years and would cumulatively represent about 0.12 percent of San Juan Basin 2015 total water withdrawals (486,660 AF). As noted above, agriculture would remain by far the largest water use within the San Juan Basin (currently 79 percent of all water use within the San Juan Basin).

4.1.4. Potential Sources of Water for Project Development

Water used for oil and gas drilling and completion would be purchased legally from those who hold water rights in or around the San Juan Basin. The transaction would be handled by the New Mexico Oil Conservation Division, as well as the New Mexico Office of the State Engineer. All water uses would be evaluated at the APD stage in site-specific NEPA analysis and subject to standard lease terms and conditions; however, it is important to note that sources of water for lease development are also not always known at the APD stage.

It is speculative to predict the actual source of water that would be used for development of the RFD (or the development of any specific lease sales). In addition to utilizing surface or groundwater, operators may also bring water to a well site via truck from any number of sources. Because most water used in mining activities in the counties that comprise the Rio Puerco FO is currently from groundwater, it is reasonable to assume that a large portion of the water used for hydraulic fracturing under the RFD scenario would likely be groundwater. Groundwater is a more readily available source of water than surface water due to the ephemeral nature of many surface water features in the San Juan Basin. Therefore, surface waters are discussed only briefly in this chapter.

The Rio Puerco FO contains many types of surface water bodies including springs, seeps, lakes, rivers, streams, and ephemeral drainages and draws. Waters from spring developments, reservoirs, streams, and stream diversions within the planning area are used primarily for irrigation, livestock, and wildlife. Diversions on BLM-managed lands support private land crop irrigation and stock water needs.

Information about the aquifers underlying the Rio Puerco FO comes primarily from the hydrologic assessment of oil and gas development in the San Juan Basin (Kelly et al. 2014), the Mancos-Gallup Resource Management Plan Amendment and EIS (BLM 2015), and from the Mancos-Gallup Resource Management Plan Amendment and Environmental Impact Statement (BLM 2015).

The geologic setting of the San Juan Basin is highly stratified and complex. Geologic processes have created both continuous and discontinuous sandstone aquifers. There are ten major confined aquifers in the San Juan Basin: Morrison Formation, Ojo Alamo Sandstone, Pictured Cliffs Sandstone, Cliff House Sandstone, Menefee Formation, Kirtland Shale/Fruitland Formation, Point Lookout Sandstone, Gallup Sandstone, Dakota Sandstone, and Entrada Sandstone" (Kelley et al. 2014). "Most of the groundwater in the San Juan Basin is developed in Cenozoic to Mesozoic sandstones that are separated by low-permeability shale to mudstone intervals" (Kelley et al. 2014:10). Table 4-11 lists the general description of the major rock units in the San Juan Basin.

Some formations within the San Juan Basin produce more water than others. Cenozoic (younger) aquifers in the San Juan Basin, such as the Ojo Alamo Sandstone, the Nacimiento Formation, and the San Juan Formation, have potential to produce water at a rate of 100 gallons per minute (gpm) (BLM 2015). Other aquifers in the San Juan Basin are known to yield water at rate of less than 20 gal/min (BLM 2015). According to Kelley et al. (2014:55), "Of the aquifers investigated in this study, the "true" Gallup Sandstone contains the least amount of water and the San Jose/Nacimiento aquifer contains the most."

In the southern portion of the San Juan Basin, water for hydraulic fracturing of oil wells comes from sources that tap the Nacimiento Formation and the Ojo Alamo Sandstone. Kelley et al. (2014:56) state that, "Water level monitoring by the U.S. Geological Survey during the 1980s reveals that long term use of a well drilled into these aquifers will cause water levels to drop, potentially affecting neighboring wells."

Table 4-12. General Description of the Major Rock Units in the San Juan Basin

Youngest	Formation	Rock Type (major rock listed first)	Resource
Cenozoic	San Jose Formation	Sandstone and shale	Water, gas
	Nacimiento Formation	Shale and sandstone	Water, gas
	Ojo Alamo Sandstone	Sandstone and shale	Water, gas
Cretaceous	Kirtland Shale	Interbedded shale, sandstone	Water, oil, gas
	Fruitland Shale	Interbedded shale, sandstone and coal	Coal, coalbed, methane
	Pictured Cliffs Sandstone	Sandstone	Oil, gas
	Lewis Shale	Shale, thin limestones	Gas
	Cliff House Sandstone	Sandstone	Oil, gas
	Menefee Formation	Interbedded shale, sandstone and coal	Coal, coalbed, methane, gas
	Point Lookout Sandstone	Sandstone	Oil, gas, water
	Crevasse Canyon Formation	Interbedded shale, sandstone and coal	Coal
	Gallup Sandstone	Sandstone, and a few shales and coals	Oil, gas, water
	Mancos Shale	Shale, thin sandstones	Oil, gas
	Dakota Sandstone	Sandstone, shale and coals	Oil, gas, water
Jurassic	Morrison Formation	Mudstones, sandstone	Uranium, oil, gas, water
	Wanakah/Summerville/Cow Springs/Bluff	Siltsone, sandstone	N/A
Oldest	Entrada Sandstone	Sandstone	Oil, gas, water

Source: Kelly et al. 2014. Table 15. Generalized description of the Cenozoic, Cretaceous, and Jurassic rock units in the San Juan Basin

4.1.5. Water Use Mitigations

Overall, there have been calls to increase the use of alternative water sources such as brackish water or recycling produced water, minimizing the strain on local freshwater resources (Kondash et al. 2018). The BLM encourages the use of recycled water in hydraulic fracturing techniques.

Moreover, recent studies indicate that the water used for hydraulic fracturing may be retained within the shale formation, with only a small fraction of the fresh water injected into the ground returning as flowback water; water returning to the surface is highly saline, is difficult to treat, and is often disposed through deep-injection wells (Kondash et al. 2018). Thus, the ability to recycle water may be more limited than previously reported. Note that water use calculations above do not assume the use of recycled water.

4.2. Water Quality

4.2.1. Groundwater

Results of the hydrologic assessment of oil and gas development of the Mancos Shale in the San Juan Basin (Kelley et al. 2014) indicate that groundwater quality in the San Juan Basin is variable (ranging from fresh to brackish) due to the complex stratigraphy and varying rock formations within the Basin. Brackish and saline water is typically found in the center of the Basin, and fresh groundwater is typically found along the Basin margins. Deep saline water can migrate upward along cracks and fissures. Fresh water along the Basin margins at depths greater than 3,500 feet indicate fast recharge rates influenced by geologic structures (Kelley et al. 2015).

The geologic formation where groundwater resides also influences groundwater salinity. Figure 4-1 (Figure 15; Kelley et al. 2014) is an illustrated geologic cross section showing the distribution of saline aquifers within the San Juan Basin.

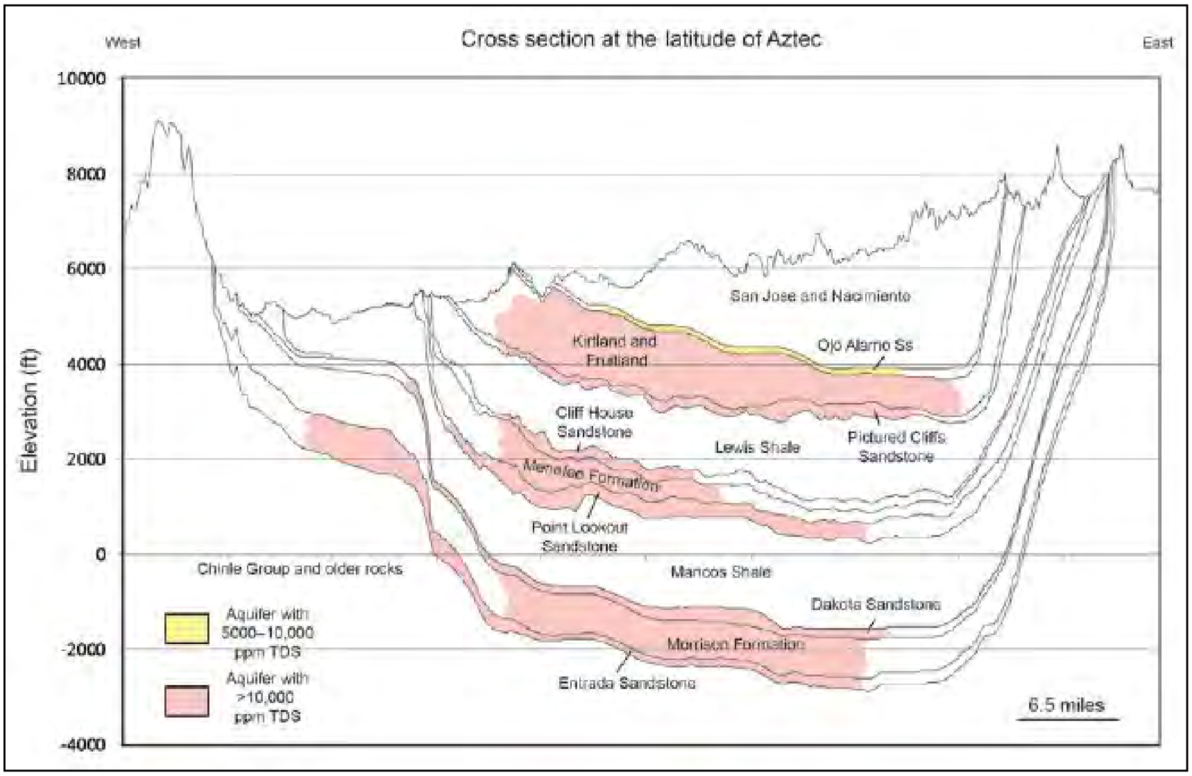


Figure 4.3. Geologic cross section showing the distribution of saline aquifers in the San Juan Basin.

Source: Figure 15 from Kelley et al. 2014.

Total dissolved solids (TDS) concentration is a measure of all the dissolved matter in a sample of water. TDS is the primary indicator of groundwater quality as higher TDS concentrations typically make water less suitable for drinking or for agricultural purposes like irrigation. In groundwater, TDS is influenced by the dissolution of natural materials such as rock, soil, and organic material. Anthropogenic activities also contribute to TDS concentrations in shallow unconfined aquifers.

TDS concentration in the San Juan Basin is dependent on the stratigraphic location and the geologic formation where the water resides. Fresh water (TDS < 1,000 milligrams per liter [mg/l]) is typically found at depths <2,500 feet (ft) below the ground surface, although exceptions to this generalization occur in deeper layers like the Gallup Sandstone and Morrison Formation. Saline and brackish water is dominant in the center of the Basin at deeper depths (Kelley et al. 2014).

4.2.2. Surface Water

Surface water quality data are limited to data gathered from perennial surface water drainages in the Rio Puerco FO. Water quality in streams flowing on BLM-managed land is influenced by both natural water quality with regard to salinity content and the intensity of human and industrial activity in the watershed. For example, water quality may be vastly different in a remote mountain spring creek than in waters with natural brine discharge, or where there are human impacts due to urban, farming, ranching, or industrial activity. Chemistry samples of surface water in the planning region are needed in order to establish a baseline chemistry data for the waters. Variances in baseline chemistry can indicate water quality changes attributable to land use development.

4.2.3. Potential Sources of Surface Water or Groundwater Contamination

Spills

Spills associated with oil and gas development may reach surface water directly during the spill event. Spills may also reach surface waters indirectly, when the spill has occurred, and a rain event moves contaminants into nearby surface water bodies through surface water flow or even subsurface groundwater flow into springs that discharge into a surface water body.

The San Juan Basin has been a producing oil and natural gas field since the early to middle 1900s. According to available GIS data, approximately 37,000 wells have been drilled within the boundary of the Farmington FO (BLM 2018). In 2017 oil and gas development resulted in 5,979,536 bbls of crude oil; 464,709,385 mcf of natural gas; and 17,068,297 bbls of produced water. As shown in Table 2-12, there were a total of 106 spills in the New Mexico portion of the San Juan Basin in 2018. The volume of spilled oil, natural gas, and produced water comprises approximately 2.0 percent, 0.0003 percent, and 0.01 percent, respectively, of 2017 oil, natural gas and produced water values. Appendix C contains a methodology for analyzing spill data.

The rate of recovery varied by spill type but in generally, about 55 percent of all spills were not recovered. Of the spills above, nine incidents were reported as having affected surface waterways: three incidents involving produced water (57 bbls, due to well equipment failure or pipeline corrosion), two incidents involving natural gas-methane (49 mcf, due to pipeline equipment failure or corrosion), one incident involving crude oil (8 bbls, due to tank or pit overflow), one incident involving condensate (3 bbls, due to flowline equipment failure), and two incidents involving other materials (240 bbls, during transport due to human error); NMOCD 2019). The BLM works with the NMOCD to remediates spills on public BLM lands. Per NMAC 19.15.29.11, the responsible person shall complete division-approved corrective action for releases that endanger public health or the environment in accordance with a remediation plan submitted to and approved by the division or with an abatement plan submitted in accordance with 19.15.30 NMAC. The remaining contaminates from unrecovered spills are remediated in accordance with federal and state standards. Some remediation consists of removing contaminated soil and replacing it uncontaminated soil and corresponding chemical testing.

Table 4-13. Summary of 2018 Spills in San Juan Basin

Spilled Material Type	Number of Spills	Volume Spilled	Volume Lost	Units	% Volume Lost
Condensate	21	403	286	Barrels	71%
Crude Oil	12	1,174	273	Barrels	23%
Lube Oil	1	23	23	Barrels	100%
Motor Oil	1	0.07	0.07	Barrels	100%
Other (Specify)	12	605	412	Barrels	68%
Produced Water	34	873	402	Barrels	46%
Total	**81**	**3,078**	**1,396**	**Barrels**	**45%**
Natural Gas (Methane) and Natural Gas Liquids	25	117,325	112,502	MCF	96%
Total Number of Spills	**106**				

Source: NMOCD 2018

Drilling and Completion Activities

The BLM and NMOCD's casing, cementing, and inspection requirements would limit the potential for groundwater reservoirs and shallow aquifers to be impacted by fracking or the migration of hydrocarbons on the nominated lease parcels. Prior to approving an APD, a BLM geologist would identify all potential subsurface formations that would be penetrated by the wellbore including groundwater aquifers and any zones that would present potential safety or health risks that would need special protection measures during drilling, or that could require specific protective well construction measures. Casing programs and cement specifications would be submitted to the BLM and NMOCD for approval to ensure that well construction design would be adequate to protect the subsurface environment, including known or anticipated zones with potential risks or zones identified by the geologist. Surface casing would be set to an approved depth, and the well casing and cementing would stabilize the wellbore and provide protection to any overlying freshwater aquifers by isolating hydrocarbon zones from overlying freshwater aquifers. Before hydraulic fracturing takes place, all surface casings and intermediate zones would be required to be cemented from the bottom of the cased hole to the surface. The cemented well would be pressure tested to ensure there are no leaks, and a cement bond log would be run to confirm that the cement has bonded to the steel casing strings and to the surrounding formations.

The BLM requires operators to comply with the regulations at 43 CFR 3160. These regulations require il and gas development to comply with directives in the Onshore Orders and the orders of the Authorized Officer. Onshore Order No. 2 and the regulations at 43 CFR 3162.3-3 provide regulatory requirements for hydraulic fracturing, including casing specifications, monitoring and recording, and management of recovered fluids. The State of New Mexico also has regulations for drilling, casing and cementing, completion, and plugging to protect freshwater zones (19.15.16 NMAC). Complying with the aforementioned regulations require producers and regulators to verify the integrity of casing and cement jobs. Casing specifications are designed and submitted to the BLM together with an APD. The BLM petroleum engineer independently reviews the drilling plan, and based on site-specific geologic and hydrologic information, ensures that proper drilling, casing and cementing procedures are incorporated in the plan in order to protect usable groundwater. This isolates usable water zones from drilling, completion/hydraulic fracturing fluids, and fluids from other mineral bearing zones, including hydrocarbon bearing zones. COAs are attached to the APD, if necessary, to ensure groundwater protection. Installation of the casing and cementing operations are witnessed by certified BLM Petroleum Engineering Technicians. At the end of the well's economic life, the operator must submit a plugging plan. The plugging plan ensures permanent isolation of usable groundwater from hydrocarbon bearing zones and is reviewed by the BLM petroleum engineer prior to well plugging. BLM inspectors ensure planned procedures are properly followed in the field.

Surface casing and cement would be extended beyond usable water zones. Production casing will be extended and adequately cemented within the surface casing to protect other mineral formations, in addition to usable water bearing zones. These requirements ensure that drilling fluids, hydraulic fracturing fluids, and produced water and hydrocarbons remain within the well bore and do not enter groundwater or any other formations. Since the advent of hydraulic fracturing, more than 1 million hydraulic fracturing treatments have been conducted, with perhaps only one documented case of direct groundwater pollution resulting from injection of hydraulic fracturing chemicals used for shale gas extraction (Gallegos and Varela 2015). Requirements of Onshore Order No. 2 (along with adherence to state regulations) make contamination of groundwater resources highly unlikely and there have not been any documented past instances of groundwater contamination attributed to well drilling. This is an indication of how effective the use of casing and cement is at preventing leaks and contamination.

CHAPTER 5. HOW TO USE THIS REPORT TO ANALYZE WATER USE ASSOCIATED WITH WELL OR LEASE DEVELOPMENT

A water use analysis for well or lease development estimates the projected water use associated with the proposed action and then compares that use to existing water use in the county or counties in which water is assumed to come from and the USGS to understand how water use would increase. This report provides existing water use for all counties within each Field Office, but the actual counties used in the analysis may vary depending on the location of the project or proposed lease sale. For the Pecos District, recent lease sale analyses have considered a three-county area (Chavez, Eddy and. Lea counties). For the Farmington FO, recent lease sale analyses have considered Rio Arriba County, San Juan Basin, and Sandoval County. For the Rio Puerco FO, recent lease analyses have considered Sandoval County or the San Juan Basin.

Two scenarios are examined for the water use analysis. The first, a maximum development scenario, examines the impacts if all wells were developed in a single year. This scenario that may not occur in all projects but provides an analysis of the largest possible impact to water quantity. The second, an RFD cenario, considers water use if the wells were to be developed over a 20-year period. This analysis is consistent with the Engler and Cather 2012, 2014 RFD, and Crocker and Glover 2018 which assumes that reasonably foreseeable future development would not all happen in the same year but would be spread over the next 20 years.

Maximum Development Scenario Calculations

Under the maximum development scenario, the calculation of water use for well development associated with an APD or lease sale is based on the number of wells and projected water use per well (which may vary by well type). The resulting water use (calculated as AF) is then compared to the existing water use in the chosen county or counties, and to the State of New Mexico to understand how water use would increase. Key reporting metrics for the maximum development scenario analysis are as follows:

1. percent contribution to total water use in the chosen county or counties (delineated in the formulas below as COUNTY/IES. This is calculated as follows:

   [(proposed action AF + total COUNTY/IES water AF) / total COUNTY/IES water AF]= x 100

2. percent contribution to groundwater use in the Pecos District. This is calculated as follows:

   [(proposed action AF + total COUNTY/IES groundwater AF) / total COUNTY/IES groundwater AF] x 100

3. percent contribution to total "Mining" water use in the Pecos District. This is calculated as follows:

   [(proposed action AF + total COUNTY/IES mining AF) / total COUNTY/IES mining AF] x 100[*]

4. percent contribution to Pecos District oil and gas water use. This is calculated as follows:

   [(proposed action AF + COUNTY/IES O&G AF) / COUNTY/IES AF] x 100

5. percent contribution to statewide oil and gas water use. This is calculated as follows:

   [(proposed action AF + statewide oil and gas AF) / statewide O&G AF] x 100

[*] This calculation could be further refined to be county-specific depending on the location and size of the project. Note also that O&G comprises a small element of Mining; see the additional calculations below to further put the impact into context.

6. percent contribution of increased Pecos District oil and gas development water use (revised as per above) to the total Pecos Mining water use. This is calculated as follows:

(new total COUNTY/IES AF as calculated above / COUNTY/IES Mining AF) x 100

7. percent contribution of increased statewide oil and gas development water use (revised as per above) to the total statewide mining water use. This is calculated as follows:

(new total statewide O&G AF as calculated above / Statewide mining AF) x 100

RFD Scenario Calculations

Under the RFD scenario, the calculation of water use for any given year is made by taking the total water use associated with the proposed action (as calculated under the maximum development scenario) and dividing by 20 (life of the RFD). Key reporting metrics for the RFD scenario analysis are as follows:

8. percent contribution to Pecos District oil and gas water use

[(per year proposed action AF + COUNTY/IES O&G AF) / COUNTY/IES O&G AF] x 100

9. percent contribution to statewide oil and gas water use

[(per year proposed action AF + statewide O&G AF) / statewide O&G AF] x 100

10. percent contribution of increased Pecos District oil and gas development water use (revised as per above) to the total Pecos Mining water use

[new total COUNTY/IES O&G AF calculated as above / COUNTY/IES mining use] x 100

11. percent contribution of increased statewide oil and gas development water use (revised as per above) to the total statewide mining water use

[new total statewide O&G AF calculated as above / statewide mining use] x 100

The following example analyzes water use in the Pecos District associated with the maximum development scenario and RFD Scenario for a proposed action of 30 horizontal wells, reporting the 10 metrics listed above.

EXAMPLE WATER USE ANALYSIS

Proposed action: 30 horizontal wells

Analysis area: Chavez, Lea and Eddy Counties

Maximum development scenario: Proposed action would require 810 AF of groundwater total

RFD Scenario: Proposed action would require 40.5 AF of groundwater in any given year

Reported Metrics:

If all wells were developed <u>in a single year</u> (a maximum development scenario), there would be:

<u>Metric #1</u>: an increase of 0.13% over 2015 Pecos District total water use

<u>Metric #2</u>: an increase of 0.15% over 2015 Pecos District total groundwater use

<u>Metric #3</u>: an increase of 0.9% over 2015 Mining water use for Pecos District

<u>Metric #4</u>: an increase of 20% over 2015 Pecos District oil and gas water use

<u>Metric #5</u>: an increase of 20% over 2015 statewide oil and gas water use

<u>Metric #6</u>: an increase in the percentage contribution of Pecos District water use associated with oil and gas development to total 2015 Pecos District mining water use, from 4.2% to 5.1%

Metric #7: an increase in the percentage contribution of statewide water use associated with oil and gas development to total 2015 statewide mining water use, from 2.4% to 2.9%

If all wells were developed over a period of 20 years (the RFD scenario), then for any given year, there would be:

Metric #8: an increase of 1% over 2015 Pecos District oil and gas water use

Metric: #9: an increase of 1% over 2015 statewide oil and gas water use

Metric #10: an increase in the percentage contribution of Pecos County water use associated with oil and gas development to total 2015 Pecos District mining water use, from 4.2% to increase to 4.3%

Metric #11: an increase of in the percentage contribution of statewide water use associated with oil and gas development to total 2015 statewide mining water use, from 2.4% to increase to 2.5%

CHAPTER 6. LITERATURE CITED

Broadhead, R. and A. J. Rinehart. 2018. The Oil and Natural Gas Potential of Sandoval county, New Mexico and its Relationship to Groundwater, with a Discussion of Modern Oil Drilling Methods and Possibilities for Aquifer Contamination. New Mexico Bureau of Geology and Mineral Resources. Available at: http://www.sandovalcountynm.gov/wp-content/uploads/2018/06/NMBGMR-SandovalAssessment-June2018.pdf. Accessed July 2019.

Bureau of Land Management (BLM). 1986. Rio Puerco Resource Management Plan and Record of Decision. Albuquerque, New Mexico.

———. 2003. *Farmington Resource Management Plan and Final Environmental Impact Statement*. U.S. Department of Interior, Bureau of Land Management., Farmington Field Office. Farmington, New Mexico.

———. 2010. Reasonable Foreseeable Development Scenario for the Fluid Mineral Development in the Rio Puerco Field Office. Rio Puerco BLM, Albuquerque, New Mexico.

———. 2015. Mancos-Gallup Resource Management Plan Amendment and Environmental Impact Statement. Assessment of the Management Situation. March 2015. Farmington Field Office. Farmington, New Mexico.

———. 2018. Internal BLM data reported to Dave Herrell, Soils and Water Specialist at New Mexico State Office.

———. 2019a. Personal communication between David Herrell, BLM and Julie Valdez, NMOSE regarding water use associated with the Navajo Power Plant.

———. 2019b. Development Planning Meeting between BLM Farmington FO and Operator at Farmington FO Office. May 24, 2019. Farmington, New Mexico.

Crocker, K., and J. F. Glover. 2018. *Reasonable Foreseeable Development Scenario for Oil and Gas Activities, Mancos-Gallup RMPA Planning Area, Farmington Field Office, northwestern New Mexico*. United States Department of Interior, Bureau of Land Management. Final Report.

Dieter, C. A., M. A. Maupin, R. R. Caldwell, M. A. Harris, T. I. Ivahnenko, J. K. Lovelace, N. L. Barber, and K. S. Linsey. 2018. Estimated use of water in the United States in 2015: U.S. Geological Survey Circular 1441, 65 p. Report and dataset available at. https://pubs.er.usgs.gov/publication/cir1441. Downloaded April 1. 2019.

Engler, T. 2013. Response to comments on the DEIS for the Ochoa Mine Project. Socorro, NM, USA. November 16.

Engler, T. W., and M. Cather. 2012. Reasonable Foreseeable Development (RFD) Scenario for the BLM. New Mexico Pecos District. Final Report. New Mexico Institute of Mining and Technology. Available at: https://eplanning.blm.gov/epl-front-office/projects/lup/64444/77502/86228/Final_Report-BLM-NMT-RFD.pdf. January 2019.

———. 2014. Update to the Reasonable Foreseeable Development (RFD) for the BLM Pecos District, SENM. Final Report. New Mexico Institute of Mining and Technology. Available at: https://eplanning.blm.gov/epl-front-office/projects/lup/64444/80056/93025/Final_Report-SENM-DEC2014_updated_RFD.pdf

FracFocus. 2017. Retrieved from FracFocus Data Download. Dataset available for download at the following: http://fracfocus.org/data-download. Downloaded December 13, 2018.

———. 2018. Retrieved from FracFocus Data Download. Dataset available for download at the following: http://fracfocus.org/data-download. Downloaded January 28, 2019.

———. 2019. Retrieved from FracFocus Data Download. Dataset available for download at the following: http://fracfocus.org/data-download. Downloaded May 2019.

Gallegos, T. J., and B. A. Varela. 2015. Trends in hydraulic fracturing distributions and treatment fluids, additives, proppants, and water volumes applied to wells drilled in the United States from 1947 through 2010—Data analysis and comparison to the literature: U.S. Geological Survey Scientific Investigations Report 2014–5131, 15 p., http://dx.doi.org/10.3133/sir20145131. Accessed February 2019.

Kelley, S., T. Engler, M. Cather, C. Pokorny, Cheng-Heng Yang, E. Mamer, G. Hoffman, J. Wilch, P. Johnson, and K. Zeigler.2014. *Hydrologic Assessment of Oil and Gas Resource Development of the Mancos Shale in the San Juan Basin*. New Mexico Bureau of Geology and Mineral Resources. Available at: https://geoinfo.nmt.edu/resources/water/projects/sjb/home.html. Accessed May 2019.

Kondash, A. J., N. E. Lauer, and A. Vengosh. 2018. The intensification of the water footprint of hydraulic fracturing. Science. Available at: https://advances.sciencemag.org/content/advances/4/8/eaar5982.full.pdf. Accessed April 1, 2019.

Lowry, Thomas S., Michael D. Schuhen, Owen W. Lofton, La Tonya N. Walker, Patricia B. Johnson, Dennis W. Powers, and Dale O. Bowman. 2018. Water Resource Assessment in the New Mexico Permian Basin. Prepared by Sandia National Laboratories. SAND2018-12018. October 2018. Available in BLM project files or by order at the following: https://classic.ntis.gov/help/order-methods/

New Mexico Office of the State Engineer (NMOSE). 2019. 2015 draft self-supplied oil and gas water withdrawal data. Available by contacting the BLM.

New Mexico Oil Conservation Division (NMOCD).2019. 2018 Spill Data. Available at: https://wwwapps.emnrd.state.nm.us/ocd/ocdpermitting/Data/Spills/Spills.aspx. Accessed April 2, 2019.

Summers, W. K., 1972, Geology and regional hydrology of the Pecos river basin, New Mexico, Open File Report #37, New Mexico Water Resources Institute, New Mexico State University, Las Cruces, New Mexico, 393 p.

Appendix A. FracFocus Data Analysis Methodology

Permian Basin

Data downloaded from FracFocus 1/28/19 for all calendar year 2018 for Chaves, Eddy, and Lea counties.

Duplicate records were eliminated (due to one record for each chemical species).

Summary stats are best estimators at this point. BLM used the mean (31.2 AF/horizontal well). Could use 95% confidence interval instead (or leave out)   Could work this into narrative.

Data downloaded from FracFocus 5/29/19 for cumulative analysis.

San Juan Basin

Data downloaded from FracFocus 1/28/19 for all calendar year 2018 for San Juan, Rio Arriba, and Sandoval counties.

Duplicate records were eliminated (due to one record for each chemical species). Summary stats are best estimators at this point,

BLM used the mean (4.84 AF/horizontal well). Could use 95% CI.   Could work into narrative.

Data downloaded from FracFocus 5/29/19 for cumulative analysis

Appendix B. Spill Data Analysis Methodology

Assumptions:

- We should reject duplicate spills records
- We should reject spills where the spill volume was 0 barrels
- We should keep the methane spills when looking at number of unique incidents (spills count), but not include them in the volume spilled because the units are MCF (not barrels).
- We should reject records where the spill type was natural gas liquid or methane but was reported in barrels (bad data)

Methodology:

Working entirely from the spills (1) tab of the San Juan Basin spills spreadsheet (starting with 1607 records):

1. Cleared all filters
2. Created a primary key for the data to identify and remove duplicates. *Primary key=Incident Number_Spilled Material*. In San Juan Basin, there were 3 duplicated spills. Removed one of each duplicated record from analysis. (***1604 records remain***)
3. Filtered on column W (County) to McKinley, Rio Arriba, San Juan, and Sandoval (***227 records remain***)
4. Removed spills where the volume spilled was 0 barrels (assumed to be bad data) Filtered on column P (Volume Spilled) to all values EXCEPT 0 (***111 records remain***)
5. Converted the one volume that was reported as GALLONS to BARRELS (***111 records remain***)
6. Rejected data where 'Spilled material' = Natural Gas (Methane) and Natural Gas Liquid, AND, 'Unit of Volume= BBL' (***106 records remain***)
7. Used Pivot Table tool to aggregate and summarize the data.

Working entirely from the spills (1) tab of the Permian Basin spills spreadsheet (starting with 1607 records):

1. Cleared all filters
2. Filtered on County column for Lea and Eddy counties (***1355 records remain***)
3. Created a primary key for the data to identify and remove duplicates. *Primary key=Incident Number_Spilled Material*. In Permian Basin, there were 14 duplicated spills. Removed one of each duplicated record from analysis. (***1341 records remain***)
4. Removed spills where the volume spilled was 0 barrels (assumed to be bad data). Filtered on 'Volume Spilled' to all values EXCEPT 0 (***1270 records remain***)
5. Converted the 8 volumes that was reported as GALLONS to BARRELS (***1270 records remain***)
6. Rejected data where 'Spilled material' = Natural Gas (Methane) and Natural Gas Liquid, AND, 'Unit of Volume= BBL' (9 records) (***1261 records remain***)
7. Entered 'BBL' as unit for spill with no units (Incident Number= nOY1812332827, Material spilled=Crude Oil) (***1261 records remain***)

On both sets of records

1. Using DATA worksheet, filtered on column AI (groundwater affected). (***0 records remain***)
2. Using DATA worksheet, filtered on column AH (waterway affected). (12 ***records remain***)
3. Removed spills where the volume spilled was 0 barrels (assumed to be bad data) (***9 records remain, all in San Juan Basin***)
4. Reviewed and summarized data (counties, volume of pill, cause and source)

Appendix C. 2019 Farmington Field Office Slick Water Stimulation Water Use Update

Purpose of the Update

Fluid mineral development in the San Juan Basin has experienced technological advances with the introduction of slick water stimulation beginning in 2015. Since the development of the Reasonable Foreseeable Development Scenario for Oil and Gas Activities, Mancos-Gallup RMPA Planning Area (Crocker and Glover 2018) additional information regarding the slick water stimulation technique has been gathered by the BLM Farmington FO . The 2018 Mancos-Gallup RFD presents the projected fluid mineral development potential for the Mancos-Gallup RMPA Planning Area, encompassing a total area of 4 million acres. Half of the total planning area (2 million acres) is located within one major horizontal oil and gas play, resulting in fluid mineral interest with" high" and "medium" development potential (Crocker and Glover 2018). The purpose of this update is to address the forecasted amount of water from the 2018 Mancos-Gallup RFD, which may be used during development of the Mancos Shale formation and Gallup Sandstone member utilizing slick water stimulation in the San Juan Basin.

Assumptions and Methodology

This update evaluates the potential water requirements for the development of the Mancos Shale and Gallup Sandstone within the San Juan Basin using the slick-water stimulation technique. Current industry trends in unconventional reservoir development have shifted to drilling of long (1- to 3- mile) horizontal laterals that are stimulated using large volumes of low-viscosity water-based fluids (slick-water stimulation). This development scenario evaluates the projected water demand of Mancos-Gallup development based on current industry expectations of lateral density. No evaluation of other factors (i.e. execution pace, reservoir recovery factor, economic results, alternative completion techniques) are made in this model.

Horizontal wells are currently stimulated during completion in short sections of laterals called stages. To date, 20 wells have been drilled using long laterals with slick-water stimulation within the Farmington FO. The water volume and stage length was averaged from the 20 wells using the APD and data from FracFocus. The equation for calculating estimated water volume is indicated below:

(Total water volume) = (stage water volume/stage length) x (number of stages/lateral length)

The total miles of lateral estimated to develop the Mancos Shale and Gallup Sandstone formations is based on the 2300 horizontal wells projected in the 2018 RFD. On average the wells would be stimulated in 2-mile laterals which would be approximately 4,600 miles, all of which are projected to be slick-water stimulated. For the 20 completed wells the Farmington FO calculated the average stage length to be 200 feet and the average water used per stage to stimulate the formation to be 334,000 gallons (~ 1 acre-foot). From the Farmington FO projected water use calculations, the Mancos Shale and Gallup Sandstone development within the high and medium potential areas would require approximately 125,000 acre-feet for the full development scenario using only slick-water stimulation techniques (see Table 1).

Context

The Colorado River Compact (The Compact) of 1922 determined how much water would be delivered downstream for use in the western states listed in The Compact. The remaining water is left to the individual states for allocation. It is the responsibility of the New Mexico Office of the State Engineer (NMOSE) to allocate remaining useable water within New Mexico and to ensure that all water is used according to state regulations and correctly reported. The authority and regulation of the NMOSE applies to water acquired for use in production and operation of oil and natural gas wells. Water use is published in a report every five years in the report titled "New Mexico Water Use By Categories", most recently published in 2015. See Chapter 3 of the Water Support document for information on the volume of water that was used specifically for hydraulic stimulation of oil and gas wells in the San Juan Basin using information from the NMOSE 2015 report.

The two general water types that may be used for slick water stimulation are categorized as "potable/fresh" and "non-potable". Any water that has Total Dissolved Solids (TDS) greater than 1,000 ppm has been defined as "non-potable" by the State of New Mexico (72-12-25 NMSA 1978), the BLM has identified anything less than 10,000 ppm to be protected in the casing rule of the BLM's Onshore Order #2 (BLM 1988). Non-potable water is outside the appropriative processes and is mainly diverted for mineral exploration purpose. Conversely, any water that is less than 1,000 ppm TDS is "potable/fresh". In general, potable water has a water right associated with it and is permitted and regulated by the NMOSE and may or may not be adjudicated.

During the process of gathering information regarding slick-water stimulation, the Farmington FO put together a questionnaire to conduct industry interviews. The questionnaire focused on estimated water use during drilling, completion, operation and production phases of oil and gas wells, with specific focus on water sources and water use associated with slick water stimulation. The questions were used to help the BLM determine how saline water is being utilized and to better understand the potential TDS levels within source water for the stimulation fluid. Onshore Order #1 (BLM 2017) requires operators to identify adequate water sources for stimulation plans as part of their APD.

Based on operator input the water used for slick-water stimulation can have high levels of TDS for the technology to be effective. The majority of operators within the San Juan Basin limit their TDS levels to 50,000 ppm for use in a slick water stimulation operation. The higher allowable TDS levels that are acceptable for slick water stimulation expand the possible water sources beyond those that are traditionally used (e.g., surface or ground water) into non-traditional sources of water (e.g. non-potable groundwater sources).

Recently, the NMOSE has received Notices of Intention (NOI) to Appropriate non-potable water from aquifers at depths 2,500 feet below ground level (BGL) or greater. The NMOSE has approved permits to drill wells within the San Juan Basin to withdraw non-potable connate water (groundwater) from the Entrada sandstone formation for use as a potential source of water for slick water stimulation operations. The Entrada sandstone formation maximum depth is approximately 9,500 feet deep. Water contained in the Entrada formation is highly saline (Kelley et al. 2014). As such, it is considered non-potable and has not been declared as an administrative aquifer by the NMOSE. NMOSE is the agency responsible for water withdrawal permitting actions. Their NOI process includes a model-based evaluation of the potential effects of proposed withdrawals and the identification of possible requirements for applicants to obtain water rights to offset any depletions identified in NMOSE's analyses prior to applicants commencing diversions.

Other sources of non-potable water that can be utilized in stimulation are "flowback fluid" and "produced water". Flowback fluid is a mixture of chemical proppant, water and sand that flows back through the well head directly after stimulation activities. Generally, 10-40% of the initial volume utilized for stimulation activities returns as flowback fluid, of this 10-40% is non-potable water that may be used in future stimulation activities. Produced water is naturally occurring water that exists in the formation that is being targeted for mineral extraction and is produced as a byproduct, therefore becoming "produced water". Based on operator input, after the initial flowback recovery of 10-40%, remaining water used for stimulation does return to the surface through production activities at a slower rate of return.

Projected Water Use Discussion

To gain the most current information, outreach was conducted with local operators actively drilling and producing mineral resources in the San Juan Basin to gather information regarding slick-water stimulation and reservoir development. According to the 20 APDs the average lateral well bore is one and a half miles (1.5) in length for a horizontal well (see Attachment 1). The estimated water use is approximately 41 acre feet (af) for slick water stimulation. Advances in horizontal drilling and completion techniques in the San Juan Basin in the past four to five (4-5) years has resulted in the ability to drill and complete horizontal laterals up to three (3) miles in length (according to operator input). Horizontal well bores are stimulated in intervals, each interval is called a stage. Refer to table 1 for number of stages dependent on length of well bore as well as the average water use of 1-3 mile laterals per completion.

Table C-1: Average volume of water required to complete 1-3 mile laterals utilizing slick water stimulation in the Mancos Shale and Gallup Sandstone formations

Miles	Number of Stages	Acre Feet
1	26	27
1.5	39	40
2	52	53
2.5	65	67
3	78	80

Conclusions

The amount of water that would be required to completely develop 4,600 miles of horizontal wells in the Mancos Shale and Gallup Sandstone formations via slick-water stimulation has been estimated to be approximately 125,000 af. The 2018 RFD estimates 2,300 horizontal wells that may be developed in 2018-2037, based on operator input the horizontal lengths will range from 1-3 miles. Current technology allows operators to utilize water with TDS of 50,000 ppm, well above the NMOSE potable water threshold of 1,000 ppm. This allows for the use of currently non-traditional potable water sources, including the connate water within the Entrada formation and recycled flowback water and produced water for use in slick water stimulation activities.

References

Bureau of Land Management (BLM). 1988. 43 CFR Part 3160 Onshore Oil and Gas Operations: Federal and Indian Oil and Gas Leases; Onshore Oil and Gas Order Number 2, Drilling Operations. Available at https://www.blm.gov/sites/blm.gov/files/energy_onshoreorder2.pdf. Accessed September 2019.

———. 2017. 43 CFR Part 3160 Onshore Oil and Gas Operations: Federal and Indian Oil and Gas Leases; Onshore Oil and Gas Order Number 1, Approval of Operations. Federal Register 82(6), Rules and Regulations. Available at: https://www.blm.gov/programs/energy-and-minerals/oil-and-gas/operations-and-production/onshore-orders. Accessed September 2019.

Crocker, K., and J. F. Glover. 2018. *Reasonable Foreseeable Development Scenario for Oil and Gas Activities, Mancos-Gallup RMPA Planning Area, Farmington Field Office, northwestern New Mexico*. United States Department of Interior, Bureau of Land Management. Final Report.

Kelley, S., T. Engler, M. Cather, C. Pokorny, Cheng-Heng Yang, E. Mamer, G. Hoffman, J. Wilch, P. Johnson, and K. Zeigler.2014. *Hydrologic Assessment of Oil and Gas Resource Development of the Mancos Shale in the San Juan Basin*. New Mexico Bureau of Geology and Mineral Resources. Available at: https://geoinfo.nmt.edu/resources/water/projects/sjb/home.html. Accessed August 2019.

New Mexico State Statutes. 2011. Chapter 72: Water Law. Available at: https://law.justia.com/codes/new-mexico/2011/chapter72/. Accessed August 2019.

Attachment C.1.

Table C.1-a. Water Use Averages from 20 APDs Using FracFocus Data

Well Name/Operator	Water Usage Per Stage	Stage Length
NEBU604_3H(BP)	517,171.19	201
NEBU602COM1H(BP)	444,653.34	149.6
NEBU604COM2H(BP)	535,124.92	200
NEBU604COM1H(BP)	526,524.65	200
NEBU605COM2H(BP)	551,075.29	205
NEBU605COM1H(BP)	427,903	165
SEscavdaUnit353H(Enduring)	160,437.94	176.64
EscavadaUnit302H(Enduring)	162,902.25	179.5
NEscavadaUnit316H(Enduring)	143,312.48	177.28
NEscavadaUnit330H(Enduring)	429,107.70	482.85
NEscavadaUnit317H(Enduring)	150,050.52	180
NEscavadaUnit318H(Enduring)	152,921.60	180
NEscavadaUnit331H(Enduring)	143,150.40	175.48
NEscavadaUnit315H(Enduring)	145,898.40	179.4
ROSAUnit641H(WPX)	468,363.91	207.3
ROSAUnit643H(WPX)	338,364.25	202.3
ROSAUnit640H(WPX)	389,188.64	200.3
ROSAUnit642H(WPX)	330,273.30	212.7
PallucheHZMC1H(Hilcorp)	207,003.06	201.25
SanJuan29-6UnitCom601_1H(Hilcorp)	458,228.90	194.9
Average	**334,082.79**	**203.525**

Table C.1-b. Projected Water Use by Lateral Length

Lateral Length (Feet)	Lateral Length (Miles)	Number of Stages	Water Used (Gallons)	Water Used (Acre Feet)
5280	1	25.94	8,667,029.18	26.60
7920	1.5	38.91	13,000,543.76	39.90
10,560	2	51.89	17,334,058	53.20
13,200	2.5	64.86	21,667,572.94	66.50
15,840	3	77.83	26,001,087.53	79.79

Appendix J

Air Impact Assessment and Greenhouse Gas Production (Downstream) Emissions

Air Impact Assessment for BLM Farmington Field Office Oil and Gas Development

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1.0 INTRODUCTION

The estimated emissions and air quality and Air Quality Related Value (AQRV) impacts from oil and gas development from the Mancos Shale modeled in the CARMMS (CARMMS 2.0 (Vijayaraghavan et al., 2017)) are used here as an estimate of impacts from development by the BLM FFO. The Mancos Shale was treated as a separate source group in the CARMMS modeling and AQ and AQRVs impacts from the Mancos Shale separately quantified, thus facilitating this analysis for the FFO RMP/EIS. This use of the modeled Mancos Shale impacts as a surrogate for the FFO may result in an over-estimate of the FFO impacts because a portion of Mancos Shale extends into Colorado. The cumulative impact of all sources modeled in CARMMS (covering Colorado and northern New Mexico) included the effect of sources in the non-Mancos portion of the FFO. Thus, emissions and impacts from the non-Mancos portion of the FFO are implicitly included in the CARMMS cumulative impacts described in this document.

1.1 Report Outline

Details of the emissions inventory for the Mancos Shale and non-Mancos Shale oil and gas sources whose impacts are assessed are provided in Section 2. Section 3 presents an analysis of modeling results in comparison with the NAAQS and FFO contributions to total air concentrations. In Section 4, PSD pollutant concentration impacts are presented at Class I and sensitive Class II areas. Visibility impacts and deposition impacts at Class I and II areas are reported in Sections 5 and 6, respectively. Changes to acid neutralizing capacity (ANC) of sensitive lakes are reported in Section 7.

2.0 EMISSIONS

The CARMMS study (version 2.0) includes emissions from oil and gas sources in the FFO. CARMMS 2.0 FFO oil and gas emissions were estimated from the Mancos Shale emission inventory. Additionally, emissions from the Intermountain West Data Warehouse (IWDW) oil and gas emission inventory are present in the FFO area for non-Mancos Shale oil and gas activity.

Oil and gas emissions occur during well development from sources such as drill rigs, hydraulic fracturing pumps, and completion venting, and during well production from sources such as tanks, process heaters, pneumatic controllers, and fugitive components. Oil and gas emission estimates per well (or other activity metric such as per unit of oil production) are typically developed from estimates of emission input factors including equipment counts per well, annual equipment operation estimates, process specific emission factors, and applicable controls. Oil and gas emission estimates per well (or other activity metric) are combined with estimates of area-wide oil and gas activity estimates to develop an area-wide well-site emission inventory.

2.1 Mancos Shale

The Mancos Shale emission inventory for CARMMS 2.0 (Vijayaraghavan et al., 2017) was developed primarily from oil and gas activity estimates and emission input factors from the initial Mancos Shale Emission Inventory Study documented in the September 2014 (Grant et al., 2014). The Mancos Shale inventory documented in the September 2014 memorandum was included in CARMMS version 1.5 (Vijayaraghavan et al., 2016). For CARMMS 2.0, the CARMMS 1.5 emission inventory was used with minor updates.

In the initial Mancos Shale emission inventory included in CARMMS 1.5 and the most recent Mancos Shale emission inventory included in CARMMS 2.0, Mancos Shale emissions are assumed to be limited to well site emissions. Emissions from new midstream infrastructure development (e.g., gas gathering/boosting compressor stations, gas processing plants) are assumed to be negligible. Mancos Shale gas gathering and boosting requirements are assumed to be met by existing infrastructure inside or in close proximity to the Mancos Shale development area.

2.1.1 Low and High Scenario Mancos Shale Activity Inputs

CARMMS 2.0 Mancos Shale activity estimates were decided in collaboration with BLM Colorado State Office Staff during the inventory development in fall 2016. Differences between CARMMS 2.0 and CARMMS 1.5 Mancos Shale oil and gas activity include a revised initial development year for oil wells (2015 in CARMMS 1.5 and 2016 in CARMMS 2.0) and reductions in gas well development rates (200 high scenario and 100 low scenario gas wells added per year in CARMMS 1.5 versus 147 high scenario and 73 low scenario gas wells added per year in CARMMS 2.0). Furthermore, the future year modeled in air quality modeling in CARMMS 1.5 was 2021 while year 2025 was modeled in CARMMS 2.0.

In CARMMS 1.5 and CARMMS 2.0, 74% of Mancos Shale gas well activity is assumed to occur in New Mexico, with remaining Mancos Shale gas well activity occurring in Colorado. All Mancos Shale oil well activity is estimated to occur in New Mexico. Most Mancos Shale activity in New Mexico occurs in FFO; a small portion of the south eastern part of Mancos Shale activity is located outside of FFO. 70% of Mancos Shale oil and gas well development is assumed to be on federal mineral estate and 30% on non-federal mineral estate. The Mancos Shale well development is summarized in Table 2-1.

Table 2-1. CARMMS 2.0 Mancos Shale low and high scenario development schedule[1].

Calendar Year	Mancos Shale-wide				Mancos Shale, New Mexico only			
	High		Low		High		Low	
	Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas
Spuds								
2015	-	-	-	-	-	-	-	-
2016	200	-	100	-	200	-	100	-
2017	200	-	100	-	200	-	100	-
2018	200	-	100	-	200	-	100	-
2019	200	147	100	73	200	108	100	54
2020	200	147	100	73	200	108	100	54
2021	200	147	100	73	200	108	100	54
2022	200	147	100	73	200	108	100	54
2023	200	147	100	73	200	108	100	54
2024	200	147	100	73	200	108	100	54
2025	200	147	100	73	200	108	100	54
Active Well Count								
2015	-	-	-	-	-	-	-	-
2016	200	-	100	-	200	-	100	-
2017	400	-	200	-	400	-	200	-
2018	600	-	300	-	600	-	300	-
2019	800	147	400	73	800	108	400	54
2020	1000	294	500	146	1000	216	500	108
2021	1200	441	600	219	1200	324	600	162
2022	1400	588	700	292	1400	432	700	216
2023	1600	735	800	365	1600	540	800	270
2024	1800	882	900	438	1800	648	900	324
2025	2000	1029	1000	511	2000	756	1000	378

2.1.1.1 Comparison to Mancos-Gallup Reasonable Foreseeable Development

The FFO Mancos-Gallup RFD[2] estimates that 3200 new oil and gas wells will be developed in the Mancos-Gallup area between 2018 and 2037. By 2025, the RFD estimates that there will be 809 new wells in the Mancos-Gallup area. In contrast, in CARMMS 2.0 it is estimated that by 2025, there will be 2756 new oil and gas wells for the high scenario and 1378 new oil and gas wells for

[1] Mancos Shale development schedule agreed to in the 5/3/16 email from Forrest Cook (BLM Colorado).
[2] BLM, 2018. Reasonable Foreseeable Development Scenario for Oil and Gas Activities Mancos-Gallup RMPA Planning Area, Farmington Field Office, Northwestern New Mexico, Final Report. February 2018.

the low scenario in the Mancos Shale in New Mexico. A vast majority of the new wells drilled in the Mancos Shale in New Mexico are within the Mancos-Gallup Planning Area. The low and high scenario CARMMS 2.0 well development estimates are conservatively high relative to the RFD baseline scenario.

2.1.2 Wellsite Emission Inventory Inputs

Well characteristics are expected to vary significantly across the Mancos Shale Play. Generally, oil dominant wells are expected to be in the southern part of the play while gas dominant wells are expected in the northern part of the play. The suite of equipment and production characteristics for Mancos Shale wells is expected differ substantially for oil dominant and gas dominant wells. Therefore, separate emission inventory calculators were developed for oil dominant and gas dominant well types with inputs tailored to each well type.

Mancos shale well site emissions were compiled primarily from typical Mancos Shale well site oil and gas equipment characteristics provided by BLM staff based on Mancos Shale well-site equipment configurations[3]. Attachment A shows CARMMS 2.0 Mancos Shale gas well site emission inventory inputs. Attachment B shows CARMMS 2.0 Mancos Shale oil well site emission inventory inputs. These inputs are comprehensive for the low and high scenarios. For the medium scenario, additional controls have been applied as described below.

2.1.2.1 <u>Medium Scenario Controls</u>

For the Mancos Shale CARMMS 2.0 medium scenario, high scenario oil and gas activity, wellsite configuration and emission rates were assumed. Additional emission controls (see Table 2) were implemented consistent with additional controls applied in several Colorado BLM Field Offices[4].

[3] Email from David Mankiewicz, BLM. January 8, 2014.

[4] Per Forrest Cook (BLM Colorado) comments provided to Ramboll Environ in a 6/16/16 email

Table 2-2. Medium scenario additional control assumptions.

Emission Source Category	Medium Scenario Controls
Stationary engines	50% electric engines (50% natural gas-powered)
Pneumatic devices	50% no-bleed (50% low-bleed)
Drilling	Tier 4 gen-set standards for all engines with a horsepower >750; final Tier 4 standards for all engines with horsepower <750
Completion/Fracking	
Blowdowns	25% gas captured and routed to VRUs or flares (75% vented)
Liquids removal system (all produced liquids)	25% taken away by pipeline (75% by truck)
Pneumatic pumps	Unchanged from the High Scenario except in cases where less than 25% of pneumatic pumps emissions are controlled; if less than 25% of pneumatic pumps emissions are controlled then the percentage of pneumatic pumps which are controlled is set to 25%
Unpaved roads dust	80% fugitive dust control
Construction fugitive dust	50% fugitive dust control
Condensate Tanks (all produced liquids)	100% of emissions are captured and controlled by VRU or flare
Truck loading emissions	100% of emissions are captured and controlled by VRU or flare
VRUs	50% of emission control devices are assumed to be VRUs (50% flares)

2.1.3 Emission Inventory

Table 3 shows 2025 Mancos Shale emissions. The fraction of federal emissions from New Mexico is small. 91% of federal NOx and 99% of federal VOC emissions are from New Mexico, with the remaining emissions accounted for by federal Mancos Shale activity in Colorado.

Table 2-3. 2025 Mancos Shale oil and gas NO_X and VOC emissions by scenario.

Scenario	NO_X Emissions (TPY)			VOC Emissions (TPY)		
	Federal	non-Fed	Total	Federal	non-Fed	Total
Mancos Shale-wide						
High	3,184	1,364	4,548	6,469	2,772	9,242
Medium	1,811	1,364	3,175	2,751	2,772	5,523
Low	1,592	682	2,274	3,235	1,386	4,621
Mancos Shale, New Mexico only						
High	2,895	1,241	4,136	6,395	2,741	9,135
Medium	1,716	1,241	2,957	2,704	2,741	5,444
Low	1,448	620	2,068	3,197	1,370	4,568
Percent of Mancos Shale-wide Emissions in New Mexico						
High	91%	91%	91%	99%	99%	99%
Medium	95%	91%	93%	98%	99%	99%
Low	91%	91%	91%	99%	99%	99%

2.2 Non-Mancos Shale Emissions

CARMMS 2.0 base year and future year emissions for non-Mancos Shale oil and gas sources in the Farmington Field Office Planning Area were obtained from the IWDW[5] 2025b inventory. Like the approach adopted in CARMMS 1.5, a new emission inventory was not developed in CARMMS 2.0 for non-Mancos Shale oil and gas activity in the FFO.

The IWDW South San Juan Basin emission inventory includes San Juan, Rio Arriba, Sandoval, and McKinley counties. The FFO includes much of the same area as the IWDW South San Juan Basin; the FFO includes all of San Juan County and parts of Rio Arriba, McKinley, and Sandoval counties. Most, but not all South San Juan Basin oil and gas emissions are expected to occur within the FFO. Estimates of the fraction of oil and gas emissions in the South San Juan Basin that are within the FFO have not been developed.

Estimates of the fraction of non-Mancos Shale activity that is from federal and non-federal mineral estate have not been developed.

The IWDW emission inventory includes a small amount of drilling (118 annual spuds) in the South San Juan basin outside of the Mancos Shale.

IWDW 2025 South San Juan Basin oil and gas emissions are shown in Table 4.

Table 2-4. 2025 non-Mancos Shale South San Juan Basin oil and gas NO_X and VOC emissions.

County	IWDW 2025b South San Juan Basin Emissions (tons/year)	
	NOx	VOC
Mckinley	229	347
Rio Arriba	14,647	20,417
Sandoval	284	504
San Juan	26,959	22,777

[5] http://views.cira.colostate.edu/tsdw/

3.0 2025 NAAQS COMPARISONS

The Comprehensive Air Quality Model with Extensions (CAMx) was used in CARMMS for the air quality analysis of emissions associated with the Mancos Shale development and other existing and future cumulative sources. CARMMS modeling was conducted for a 2011 base case year and a 2025 future year scenario across three oil and gas development scenarios (High, Low and Medium). Several "Source Groups" are modeled to estimate impacts from different groups of sources or regions such as individual BLM field offices and other regional sources. As mentioned previously, ***the modeled Mancos Shale impacts are used to represent FFO air impacts here and in subsequent sections.***

In this section, concentrations modeled with CAMx for High, Low and Medium Development scenarios in 2025 are compared with the NAAQS. For the ozone NAAQS analysis, the results are analyzed using both the absolute CAMx 2025 modeling results as well as using the CAMx 2011 and 2025 modeling results in a relative fashion to scale the observed Design Value Base (DVB) to project future year 2025 Design Value Future (DVF) as recommended by EPA (2007).

3.1 Ozone NAAQS Analysis using the Absolute Modeling Results

The CAMx source apportionment absolute modeling results in the 2025 High, Low and Medium Development Scenarios are analyzed and compared to the NAAQS in this section. The ozone NAAQS is defined as the three-year average of the 4th highest daily maximum 8-hour (DMAX8) ozone concentration. Since CARMMS 2.0 only uses one year of meteorology (2011), the 2025 4th highest DMAX8 ozone concentration is used as a pseudo-NAAQS comparison metric. The contribution of each Source Group to total modeled ozone at each grid cell of the 12/4 km horizontal resolution modeling domain is obtained as the ozone concentration from each Source Group at the time when the 4th highest DMAX8 ozone concentration occurred. The contribution of each Source Group to modeled 2025 4th high DMAX8 ozone greater than the NAAQS (i.e., 71.0 ppb or greater) is also analyzed.

3.1.1 Contributions of Source Groups to 4th High DMAX8 Ozone

Figure 3-1 displays spatial plots of the 4th highest DMAX8 ozone due to all cumulative sources for the 2011 Base Case and the 2025 High Development Scenario and their differences, and the 4th highest DMAX8 ozone for the 2025 scenario ozone contributions from natural emissions. This last display was generated to determine whether exceedances of the NAAQS could have been primarily due to natural emissions. The color scale in Figure 5-5 has a sharp contrast from green to yellow when an exceedance of the ozone NAAQS occurs (i.e., 71.0 ppb or higher). Figure 3-2 and Figure 3-3 are similar displays for the 2025 Low Development Scenario and 2025 Medium Development Scenario, respectively.

For the 2011 Base Case, there are vast regions where the modeled 2025 4th high DMAX8 ozone exceeds the NAAQS (Figure 3-1, top left) in the domain, while natural fires lead to the highest ozone along NM/AZ boarder and near Los Alamos of NM.

In the 2025 High, Low and Medium Development Scenarios, the areas of ozone exceedances decrease from the Base Case. The 2025 – 2011 ozone differences (bottom lefts) show decreases in almost all areas, with largest reductions of -8.3, -9.2, and -8.4 ppb for the High, Low and Medium Scenarios, respectively. The largest increase of ozone of 5.2 ppb is found in the Moffat County of NM in all three scenarios. The contribution of natural emissions to the modeled 4th highest daily maximum 8-hour ozone concentrations (bottom rights) confirms the extraordinary contribution from natural wild fires, with a maximum contribution at 61.3 ppb.

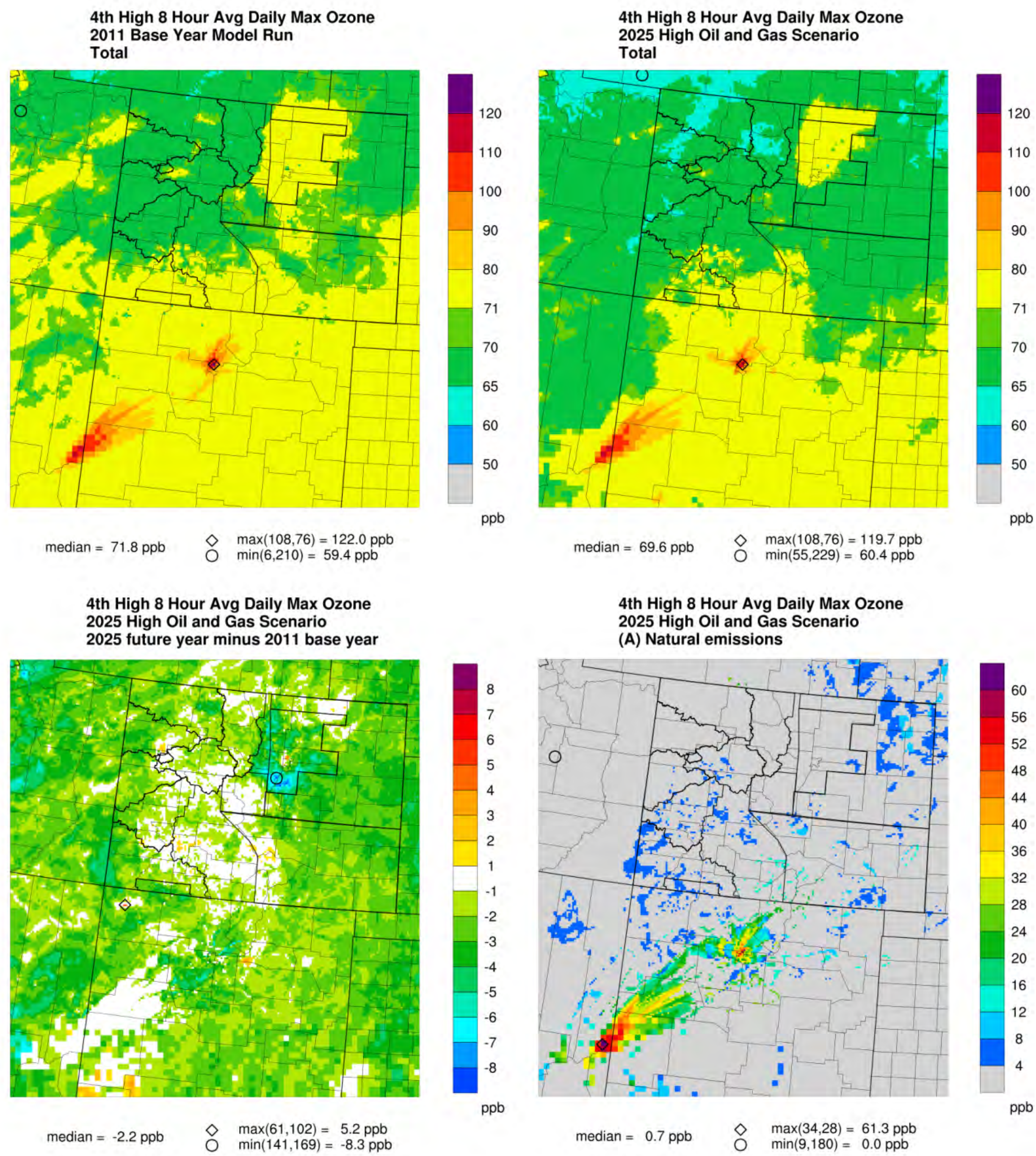

Figure 3-1. Fourth highest daily maximum 8-hour ozone concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 High minus 2011 differences (bottom left) and Natural Emissions (bottom right).

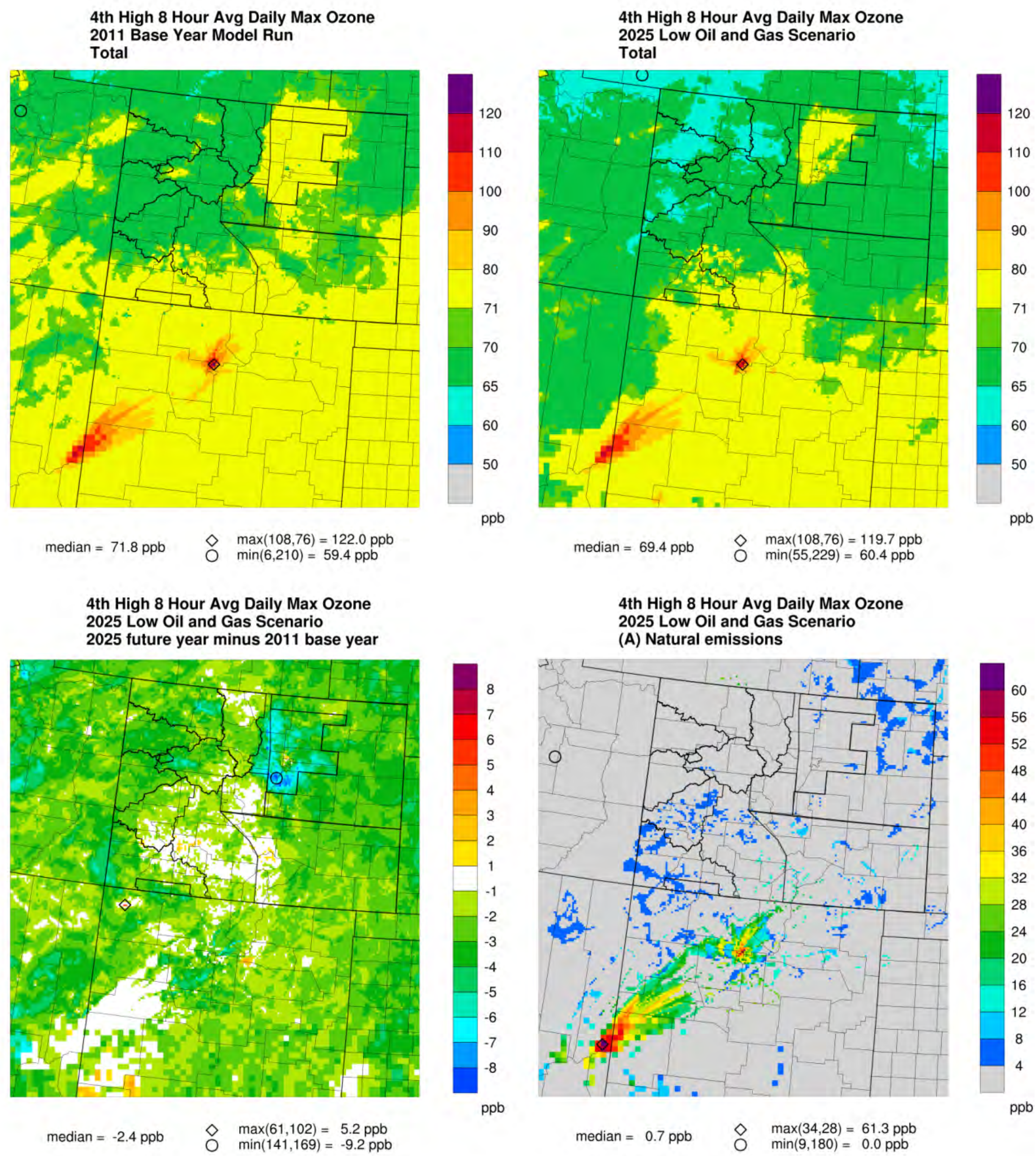

Figure 3-2. Fourth highest daily maximum 8-hour ozone concentrations for the 2011 Base Case (top left), 2025 Low Development Scenario (top right), 2025 Low minus 2011 differences (bottom left) and Natural Emissions (bottom right).

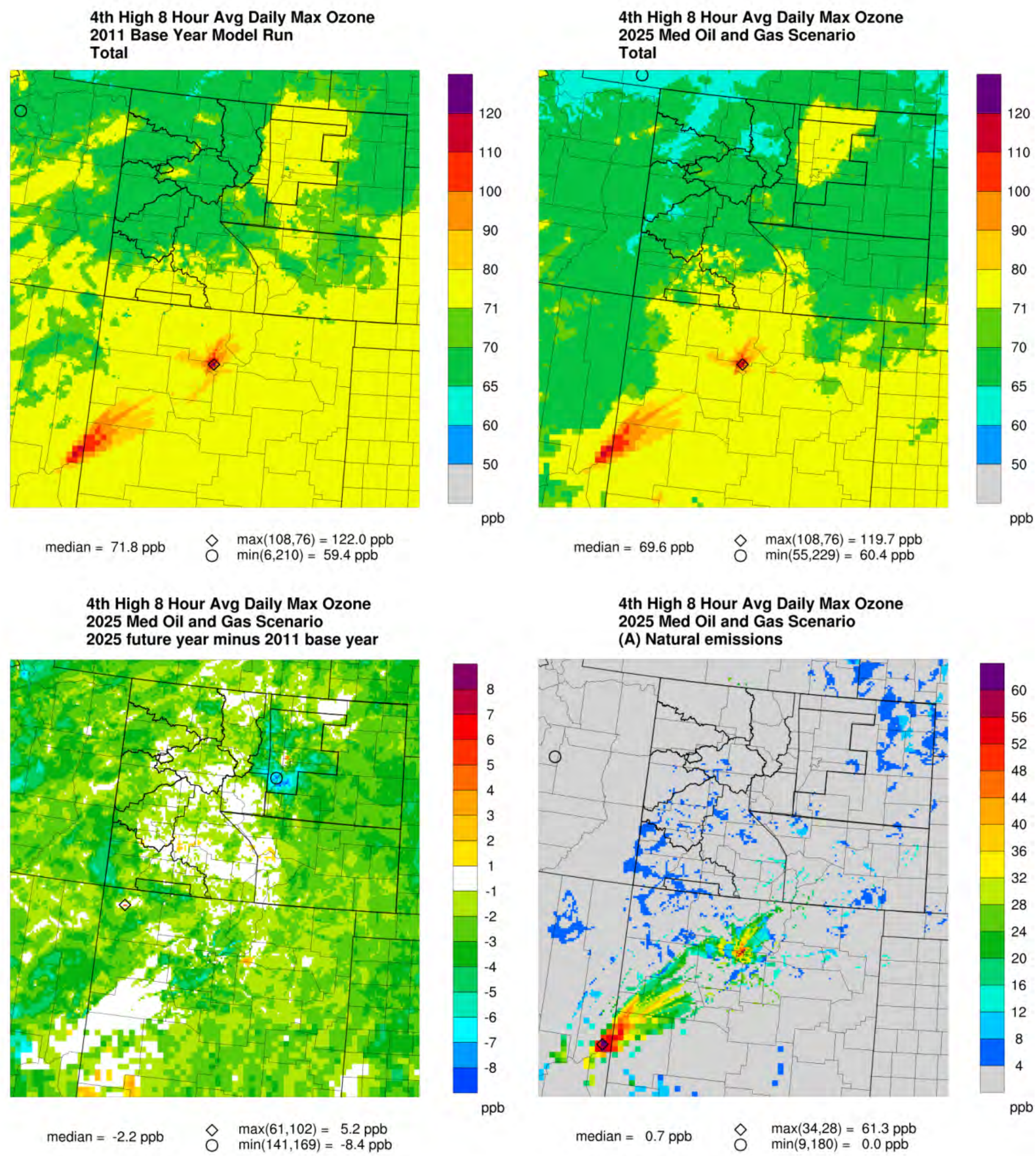

Figure 3-3. Fourth highest daily maximum 8-hour ozone concentrations for the 2011 Base Case (top left), 2025 Medium Development Scenario (top right), 2025 Medium minus 2011 differences (bottom left) and Natural Emissions (bottom right).

Figure 3-4 displays spatial plots of the New Mexico FFO contribution to the 4th highest DMAX8 ozone for the 2025 High, Low and Medium Development Scenarios. Note that these are FFO contributions to the 4th highest DMAX8 ozone and could occur when the total 4th highest DMAX8 ozone is less or greater than the ozone NAAQS. The maximum ozone contributions to the 4th highest DMAX8 ozone for the natural source group, total source groups and the New Mexico FFO source group are summarized in

Table 3-1. The next section discusses the New Mexico FFO contributions only when the total 4th high DMAX8 ozone exceeds the ozone NAAQS. Maximum ozone contributions to the 2025 4th highest DMAX8 ozone due to the New Mexico FFO are 1.7 ppb, 0.9 ppb and 1.0 ppb for the 2025 High, Low and Medium Development Scenarios, respectively.

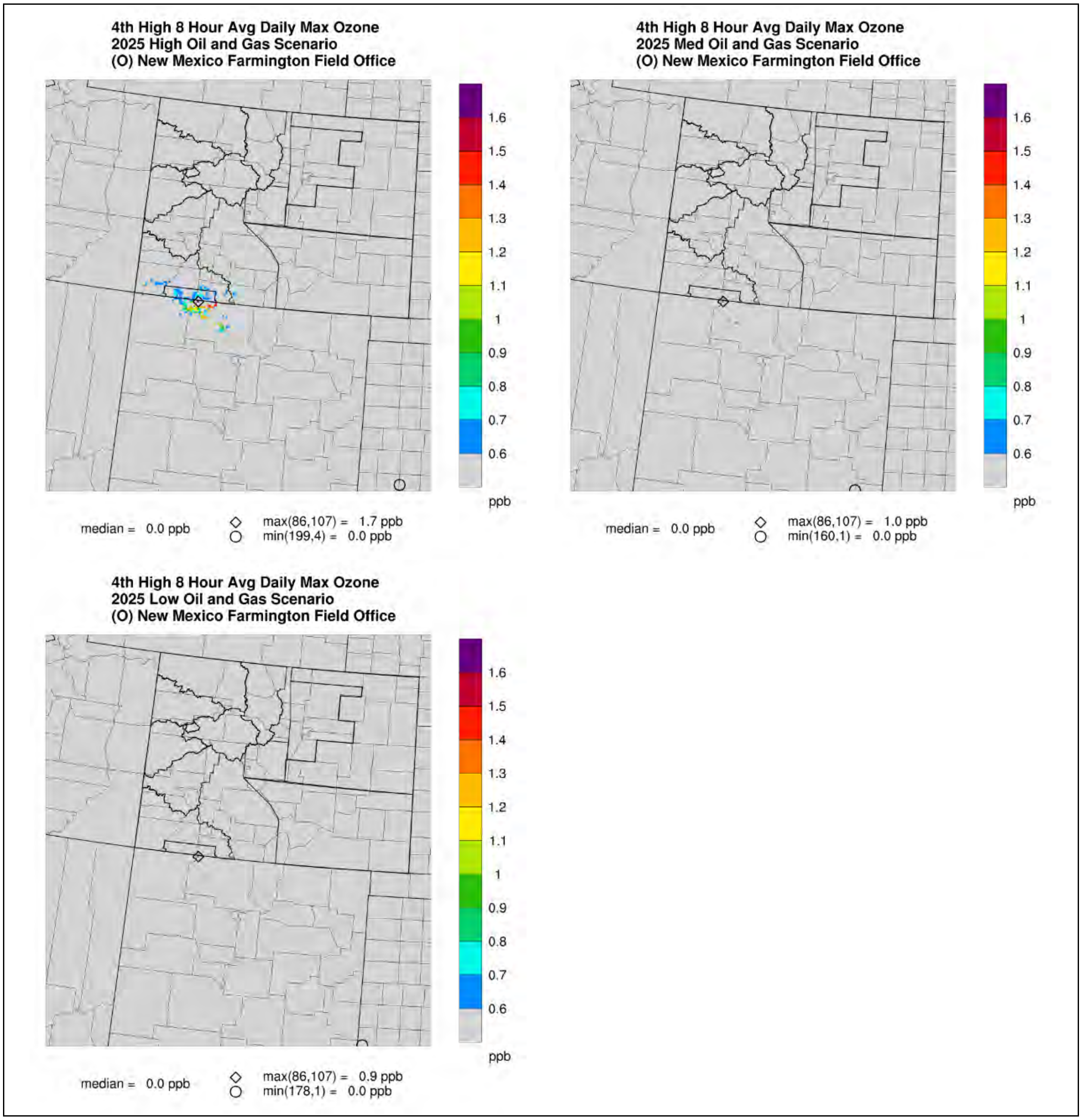

Figure 3-4. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from New Mexico Farmington Field Office for the 2025 High (top left), Low (bottom) and Medium (top right) Development Scenarios

Table 3-1. Maximum contribution to the 4th highest DMAX8 ozone (ppb) for Natural Sources, total 2011 Base Case Emissions, total 2025 High, Low and Medium Development Scenarios and the New Mexico FFO for each Development scenarios.

Source Group	High	Low	Medium
Natural Emissions	61.3	61.3	61.3
New Mexico FFO	1.7	0.9	1.0
2011 Base	122.0	122.0	122.0
2025 Scenario	119.7	119.7	119.7

3.1.2 New Mexico FFO Absolute Contributions to Ozone NAAQS Exceedances

The contributions of the New Mexico FFO ozone to the 4th highest DMAX8 ozone above the current ozone NAAQS (71.0 ppb and higher) for the 2025 High, Low and Medium Development Scenarios are shown in Figure 3-5, and the maximum contributions are reported in Table 3-2. Note that the maximum values are lower than those reported in the previous section, since these values correspond only to regions (i.e. gridcells) with 4th highest DMAX8 ozone that exceeds the 70 ppb ozone NAAQS.

Table 3-2. Maximum ozone contribution by New Mexico FFO to total modeled 2025 4th high DMAX8 ozone greater than the NAAQS for the 2025 High, Low and Medium Development Scenarios.

FFO Scenario	Maximum Contribution (ppb)	Corresponding 4th MDA8 (ppb)	% Maximum Contribution
2025 High	1.4391	71.7	2.01
2025 Low	0.6111	72.6	0.84
2025 Medium	0.6562	72.8	0.90

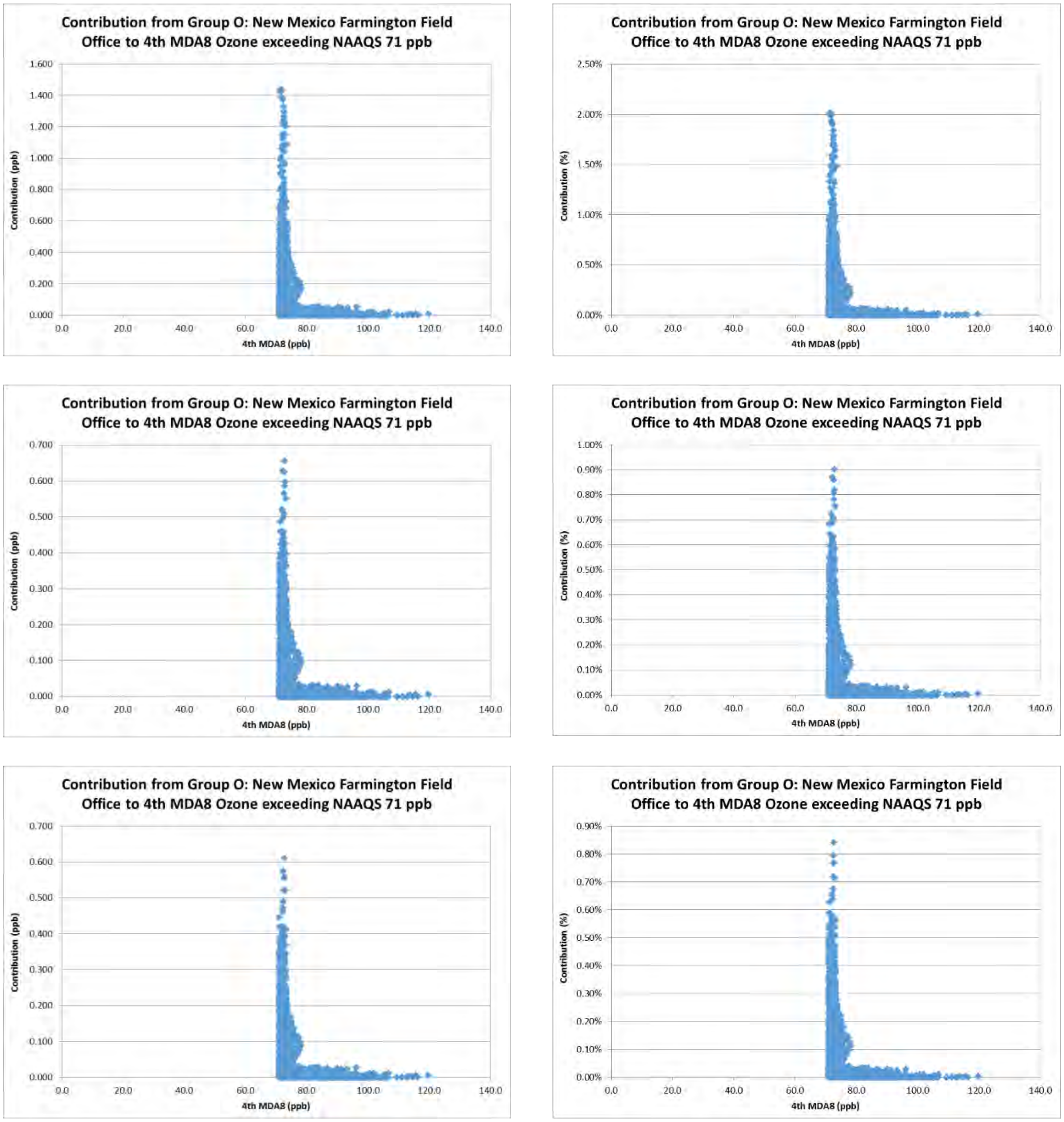

Figure 3-5. Contributions of New Mexico FFO to modeled fourth highest daily maximum 8-hour ozone concentrations greater than the NAAQS for the 2025 High (top), Middle (middle) and Low (bottom) Development Scenarios, in absolute terms (left; ppb) and as a percentage of total fourth highest DMAX8 (right; %).

3.2 Ozone NAAQS Analysis using Relative Modeling Results

EPA's Model Attainment Test Software (MATS) was used to make future year ozone DVF projections using the CAMx 2011 Base Case and 2025 High and Low Development Scenario modeling results. MATS was also used to make 2025 ozone DVF projections at the monitoring sites as well as throughout the CARMMS modeling domain using the MATS Unmonitored Area Analysis (UAA) procedures.

3.2.1 Ozone Design Value Projections at Monitoring Sites

The results of the 2025 ozone DVF projections at the monitoring sites are shown in Table 3-3. The maximum DVB (based on 2009-2013 observations) is 80.7 ppb at the CO_Douglas_0004 monitor in Douglas, CO, which is projected to be reduced to 74.5, 73.5 and 74.4 ppb for the 2025 High, Low and Medium Development Scenarios, respectively. There are 26 (out of 55) monitoring sites in the CARMMS 12/4 km domain with DVB above the ozone NAAQS (i.e., DVB ≥ 71 ppb). We note that 71 ppb is used for comparison rather than 70 ppb because EPA recommends rounding 8-hr ozone design values to the tenths digit until the last step in the MATS calculation when the final base or future design value is truncated to the nearest ppb. We also note that the ozone NAAQS is based on a 3-year average while the DVB is based on a 5-year observational period. Because DVBs are available here from the MATS analysis, they are compared to the NAAQS as they provide a measure of the severity of ozone concentrations in the base time period (here 2009-2013). The number of sites with DVF above the NAAQS is reduced to 8, 6, and 8 in the 2025 High, Low, and Medium emission scenarios, respectively.

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Table 3-3. Current year ozone Base Design Values (DVB) and projected 2025 future year ozone Design Values (DVF) for the 2025 High, Medium and Low Development Scenarios.

CID	Name	Lat	Long	State	County	DVB	DVF		
							2025 High	2025 Medium	2025 Low
040170119	AZ_Navajo_0119	34.82251	-109.89249	Arizona	Navajo	68.7	65.0	65.0	64.9
080013001	CO_Adams_3001	39.838119	-104.94984	Colorado	Adams	73.5	69.9	69.8	68.8
080050002	CO_Arapahoe_0002	39.567887	-104.957193	Colorado	Arapahoe	76.7	71.7	71.6	70.8
080050006	CO_Arapahoe_0006	39.638522	-104.569335	Colorado	Arapahoe	72.7	66.5	66.4	65.9
080130011	CO_Boulder_0011	39.957212	-105.238458	Colorado	Boulder	74.7	69.7	69.6	68.6
080310014	CO_Denver_0014	39.751761	-105.030681	Colorado	Denver	71.0	69.0	68.9	67.9
080310025	CO_Denver_0025	39.704005	-104.998113	Colorado	Denver	65.0	63.5	63.4	62.6
080350004	CO_Douglas_0004	39.534488	-105.070358	Colorado	Douglas	80.7	74.5	74.4	73.5
080410013	CO_El Paso_0013	38.958341	-104.817215	Colorado	El Paso	71.0	65.3	65.3	65.0
080410016	CO_El Paso_0016	38.853097	-104.901289	Colorado	El Paso	72.7	67.1	67.0	66.6
080450012	CO_Garfield_0012	39.54182	-107.784125	Colorado	Garfield	65.0	63.8	63.4	60.3
080590002	CO_Jefferson_0002	39.800333	-105.099973	Colorado	Jefferson	74.0	71.2	71.1	70.0
080590005	CO_Jefferson_0005	39.638781	-105.13948	Colorado	Jefferson	75.7	70.3	70.2	69.2
080590006	CO_Jefferson_0006	39.912799	-105.188587	Colorado	Jefferson	80.3	75.3	75.2	74.1
080590011	CO_Jefferson_0011	39.743724	-105.177989	Colorado	Jefferson	78.7	73.8	73.7	72.8
080590013	CO_Jefferson_0013	39.541515	-105.29841	Colorado	Jefferson	74.5	67.7	67.6	66.7
080671004	CO_La Plata_1004	37.30389	-107.484167	Colorado	La Plata	72.7	70.0	69.7	69.6
080677001	CO_La Plata_7001	37.13678	-107.62863	Colorado	La Plata	68.7	65.1	64.6	64.5
080690007	CO_Larimer_0007	40.27813	-105.54564	Colorado	Larimer	75.7	70.2	70.1	68.8
080690011	CO_Larimer_0011	40.592543	-105.141122	Colorado	Larimer	78.0	75.2	75.1	73.3
080690012	CO_Larimer_0012	40.642103	-105.275029	Colorado	Larimer	71.0	67.7	67.6	65.9
080691004	CO_Larimer_1004	40.57747	-105.07892	Colorado	Larimer	68.7	66.5	66.4	64.9
080770020	CO_Mesa_0020	39.130575	-108.313835	Colorado	Mesa	67.0	64.8	64.6	63.7
080830006	CO_Montezuma_0006	37.350054	-108.592334	Colorado	Montezuma	67.3	64.4	64.3	64.2
080830101	CO_Montezuma_0101	37.1984	-108.49046	Colorado	Montezuma	68.3	65.3	65.1	65.0
081030005	CO_Rio Blanco_0005	40.038889	-107.8475	Colorado	Rio Blanco	63.0	61.7	61.5	60.0
081030006	CO_Rio Blanco_0006	40.086944	-108.761389	Colorado	Rio Blanco	77.0	74.7	74.6	74.3
081230009	CO_Weld_0009	40.386368	-104.73744	Colorado	Weld	74.7	72.2	72.1	71.1
350010023	NM_Bernalillo_0023	35.1343	-106.5852	New Mexico	Bernalillo	68.0	65.6	65.6	65.6
350010024	NM_Bernalillo_0024	35.0631	-106.578785	New Mexico	Bernalillo	69.3	66.1	66.0	66.0
350010027	NM_Bernalillo_0027	35.1539	-106.69715	New Mexico	Bernalillo	70.0	67.2	67.2	67.2
350010029	NM_Bernalillo_0029	35.01708	-106.65739	New Mexico	Bernalillo	68.7	65.2	65.2	65.2
350010032	NM_Bernalillo_0032	35.06407	-106.76151	New Mexico	Bernalillo	70.0	67.2	67.2	67.2
350011012	NM_Bernalillo_1012	35.1852	-106.50815	New Mexico	Bernalillo	72.0	68.5	68.4	68.4
350011013	NM_Bernalillo_1013	35.19324	-106.613815	New Mexico	Bernalillo	68.7	65.9	65.8	65.8
350431001	NM_Sandoval_1001	35.299444	-106.548333	New Mexico	Sandoval	61.7	59.3	59.3	59.3
350439004	NM_Sandoval_9004	35.615278	-106.724444	New Mexico	Sandoval	62.0	60.1	60.1	60.0
350450009	NM_San Juan_0009	36.742222	-107.976944	New Mexico	San Juan	65.3	62.8	62.5	62.4
350450018	NM_San Juan_0018	36.80973	-107.65158	New Mexico	San Juan	71.0	68.0	67.7	67.5
350451005	NM_San Juan_1005	36.796667	-108.4725	New Mexico	San Juan	66.0	63.4	63.3	63.2
350490021	NM_Santa Fe_0021	35.61975	-106.07968	New Mexico	Santa Fe	64.3	62.2	62.2	62.2
350610008	NM_Valencia_0008	34.8147	-106.7396	New Mexico	Valencia	68.5	66.6	66.6	66.6
483819991	TX_Randall_9991	34.8803	-101.6649	Texas	Randall	73.0	69.7	69.7	69.7
490071003	UT_Carbon_1003	39.60996	-110.800749	Utah	Carbon	69.0	65.9	65.9	65.9
490110004	UT_Davis_0004	40.902967	-111.884467	Utah	Davis	69.3	65.0	65.0	65.0
490131001	UT_Duchesne_1001	40.208652	-110.841056	Utah	Duchesne	68.0	64.1	64.1	64.1
490352004	UT_Salt Lake_2004	40.736389	-112.210278	Utah	Salt Lake	74.0	69.4	69.4	69.3
490353006	UT_Salt Lake_3006	40.736389	-111.872222	Utah	Salt Lake	75.0	70.4	70.4	70.4
490370101	UT_San Juan_0101	38.45832	-109.82126	Utah	San Juan	68.7	65.8	65.7	65.5
490450003	UT_Tooele_0003	40.543309	-112.299618	Utah	Tooele	72.0	67.4	67.4	67.4
490490002	UT_Utah_0002	40.253611	-111.663056	Utah	Utah	70.0	66.4	66.4	66.4
490495010	UT_Utah_5010	40.136336	-111.660502	Utah	Utah	69.3	65.4	65.4	65.4
490570002	UT_Weber_0002	41.206321	-111.975524	Utah	Weber	71.7	67.3	67.3	67.3
560070100	WY_Carbon_0100	41.386944	-107.616667	Wyoming	Carbon	63.0	60.5	60.5	60.1
560210100	WY_Laramie_0100	41.182227	-104.778334	Wyoming	Laramie	68.0	66.3	66.3	65.5

3.2.2 Ozone Design Value Projection Unmonitored Area Analysis

MATS was used to perform an unmonitored area analysis (UAA) of the 2025 ozone DVF projections for the 2025 High, Low and Medium Development Scenarios. The MATS UAA interpolates the current year observed ozone DVBs across the CARMMS 12/4 km domain and then makes 2025 ozone DVF projections throughout the domain using the relative change in the CAMx 2011 and 2025 modeling results in each 12/4 km grid cell. Figure 3-6, Figure 3-7 and Figure 3-8 display the spatial distribution of the MATS UAA derived 2011 ozone DVBs and 2025 ozone DVFs and their differences for the 2025 High, Low and Medium Development Scenarios, respectively. The color scheme for the spatial plots has a cut-point at 71.0 ppb so tiles that are yellow or warmer indicate exceedances of the 0.070 ppm ozone NAAQS.

The current year DVBs indicate areas of ozone exceedances in and around Denver, places in Utah, Arizona, New Mexico, and Texas, with a maximum DVB of 109.6 ppb next to the AZ/NM boarder that is found to be caused by wild fire emissions (Figure 3-1). For the 2025 High, Low and Medium Development Scenarios the areas of 2025 ozone DVF exceedances are substantially reduced, while the natural wild fire emissions lead to 108.8 ppb of maximum DVF for all three scenarios near the AZ/NM boarder (top right in Figure 3-1,Figure 3-2, and Figure 3-3). The 2025 DVF – 2011 DVB difference plots (Figure 3-6, Figure 3-7, and Figure 3-8, bottom) shows ozone reductions with the largest reduction in the Denver metropolitan area.

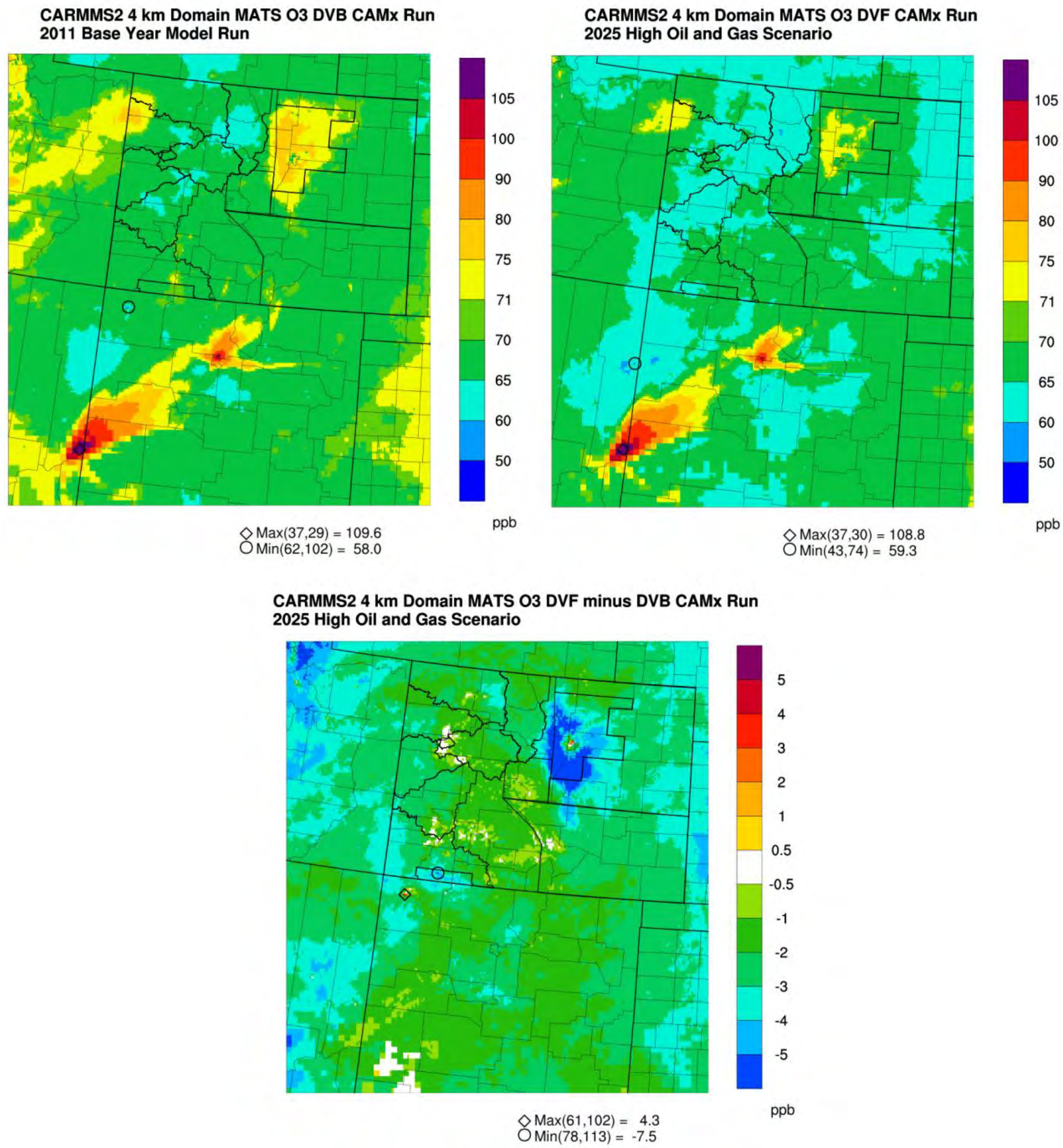

Figure 3-6. 2011-centered ozone DVB (top left), 2025 High Development Scenario ozone DVF (top right) and their differences (2025 High – 2011) (bottom) calculated using MATS.

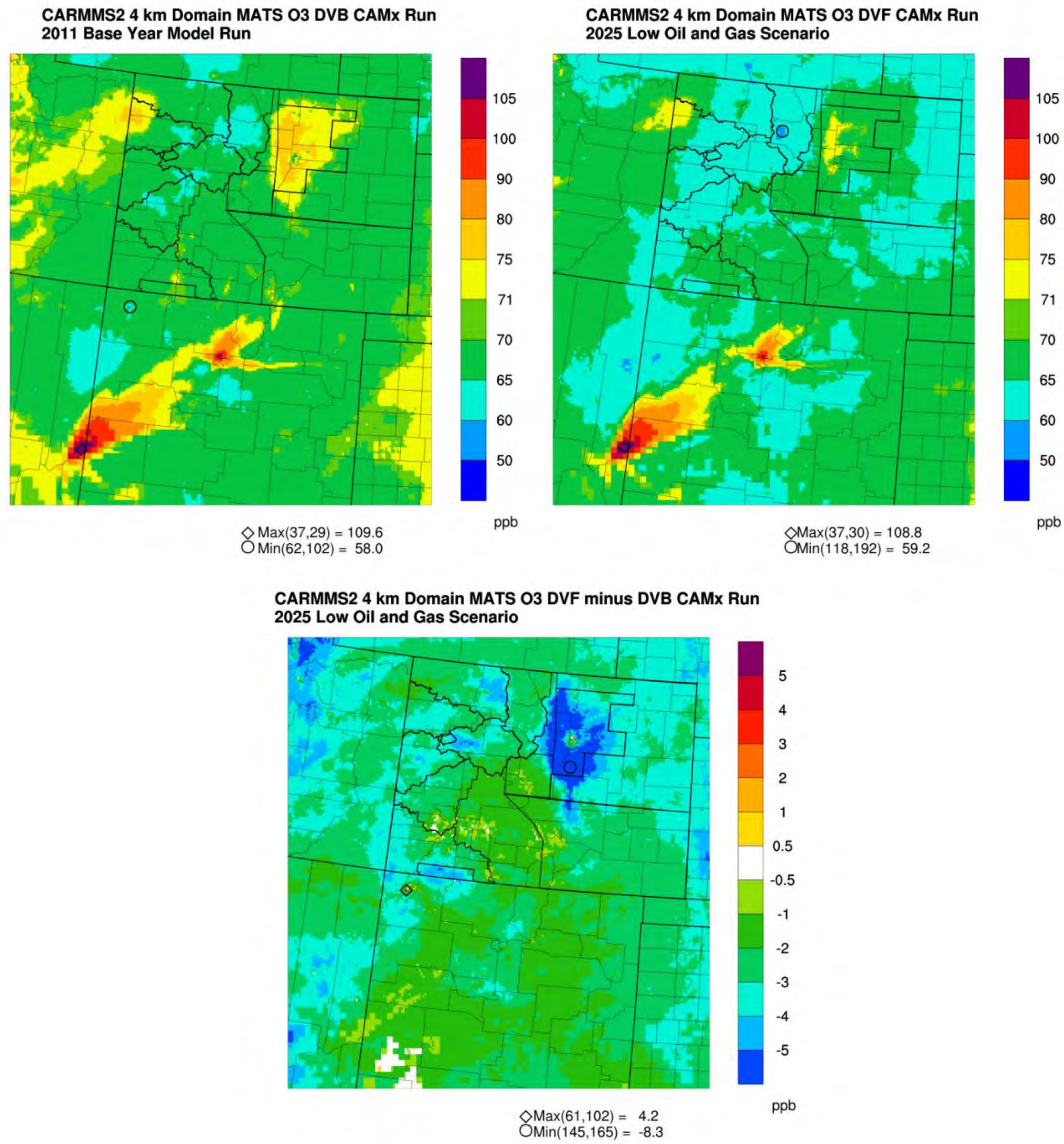

Figure 3-7. 2011-centered ozone DVB (top left), 2025 Low Development Scenario ozone DVF (top right) and their differences (2025 Low – 2011) (bottom) calculated using MATS.

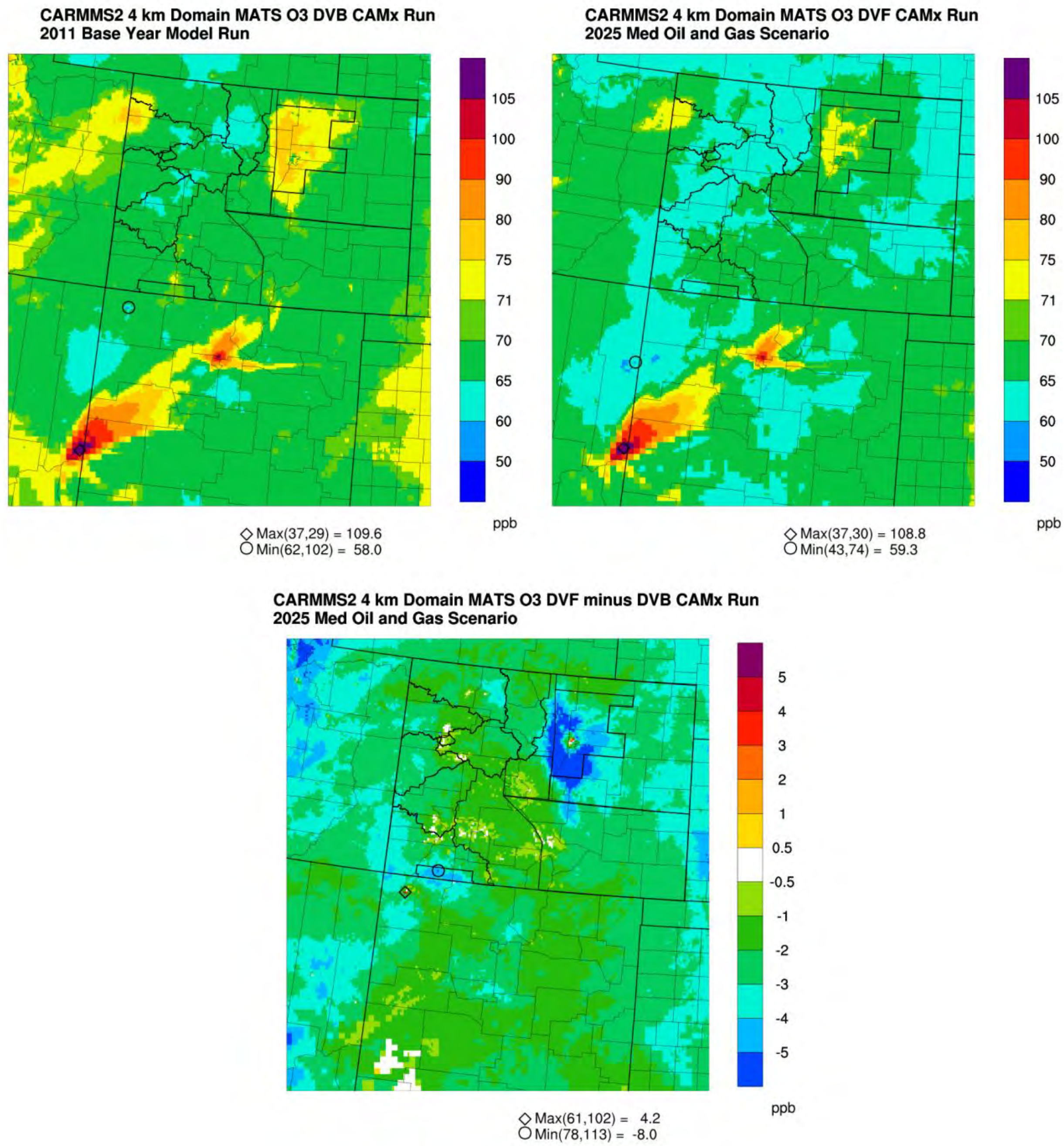

Figure 3-8. **2011-centered ozone DVB (top left), 2025 Medium Development Scenario ozone DVF (top right) and their differences (2025 Medium – 2011) (bottom) calculated using MATS.**

3.3 $PM_{2.5}$ NAAQS Analysis

There are two $PM_{2.5}$ NAAQS, one for a 24-hour averaging time that is expressed as a three-year average of the 98th percentile value in a year with a threshold of 35 µg/m^3 and an annual average over three-years with a threshold of 12 µg/m^3. With a complete year of modeling results, the 98th percentile corresponds to the 8th highest daily $PM_{2.5}$ concentration in a year.

3.3.1 24-Hour $PM_{2.5}$ NAAQS Analyses

Figure 3-9, Figure 3-10, and Figure 3-11 display the 8th highest 24-hour $PM_{2.5}$ concentrations for the 2011 Base Case and 2025 emission scenarios and their differences and the contributions of Natural Emissions to the 8th highest 24-hour $PM_{2.5}$ concentration for the High, Low and Medium Development Scenarios, respectively. The maximum 8th high 24-hour $PM_{2.5}$ in 2011 (421.3 µg/m^3) and 2025 High, Low and Medium Development Scenarios (420.9 µg/m^3) far exceed the 35 µg/m^3 NAAQS (top panels). These high values occur on the AZ/NM boarder and are largely due to emissions from wildfires (406.5 µg/m^3), as shown from the maps of contributions by Natural Emissions (bottom right panels). The greater Denver area shows exceedances in 2011 Base case and all three 2025 Scenarios. The maps of the differences between the 2025 Scenarios and 2011 Base case (bottom left panels) show decreases of $PM_{2.5}$ concentrations in most of the domain but also increases in a number of regions, including Denver, eastern Utah, and central and Northwestern New Mexico.

Figure 3-12 shows the contribution of New Mexico FFO to 8th highest 24-hour $PM_{2.5}$ concentrations in the three 2025 Development Scenarios. The peak 8th highest daily $PM_{2.5}$ concentrations are 0.8, 0.4 and 0.4 µg/m^3 in the 2025 High, Low and Medium Development Scenarios, respectively.

Table 3-4 summarizes the maximum contribution to the 8th highest 24-hour $PM_{2.5}$ concentrations for the natural Source Group, total Source Groups and the New Mexico FFO Source Group for the 2025 High, Low and Medium Development Scenarios.

Table 3-4. Maximum contribution to the 8th high 24-hour $PM_{2.5}$ concentrations (µg/m^3) for each of the Natural Source Group, Total Source Groups and New Mexico FFO 2025 High, Low and Medium Development Scenarios.

Source Group	High (µg/m^3)	Low (µg/m^3)	Medium (µg/m^3)
Natural Emissions	406.5	406.5	406.5
New Mexico FFO	0.8	0.4	0.4
2011 Total	421.3	421.3	421.3
2025 Total	420.9	420.9	420.9

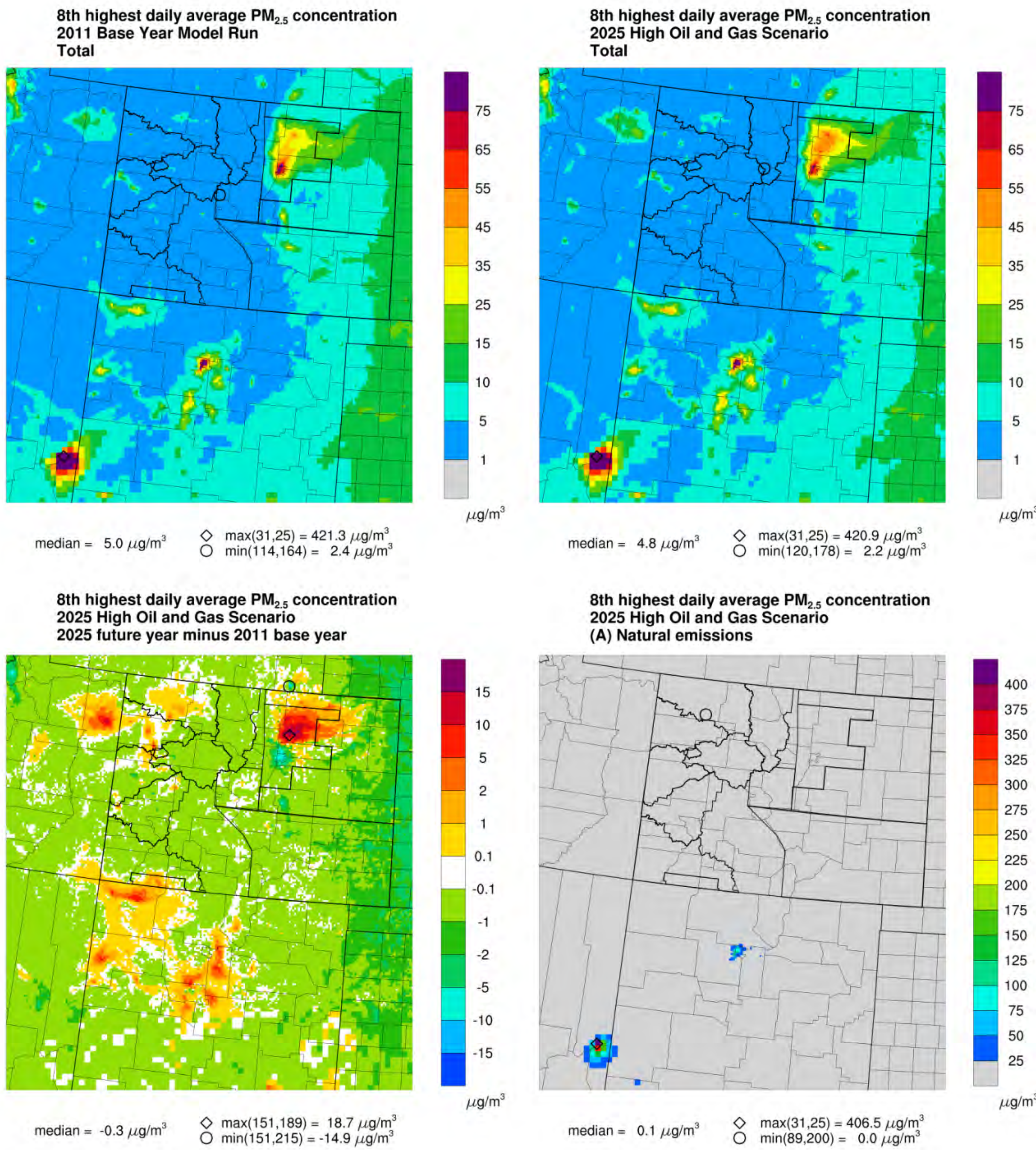

Figure 3-9. Eighth highest 24-hour $PM_{2.5}$ concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 High minus 2011 differences (bottom left) and Natural Emissions (bottom right).

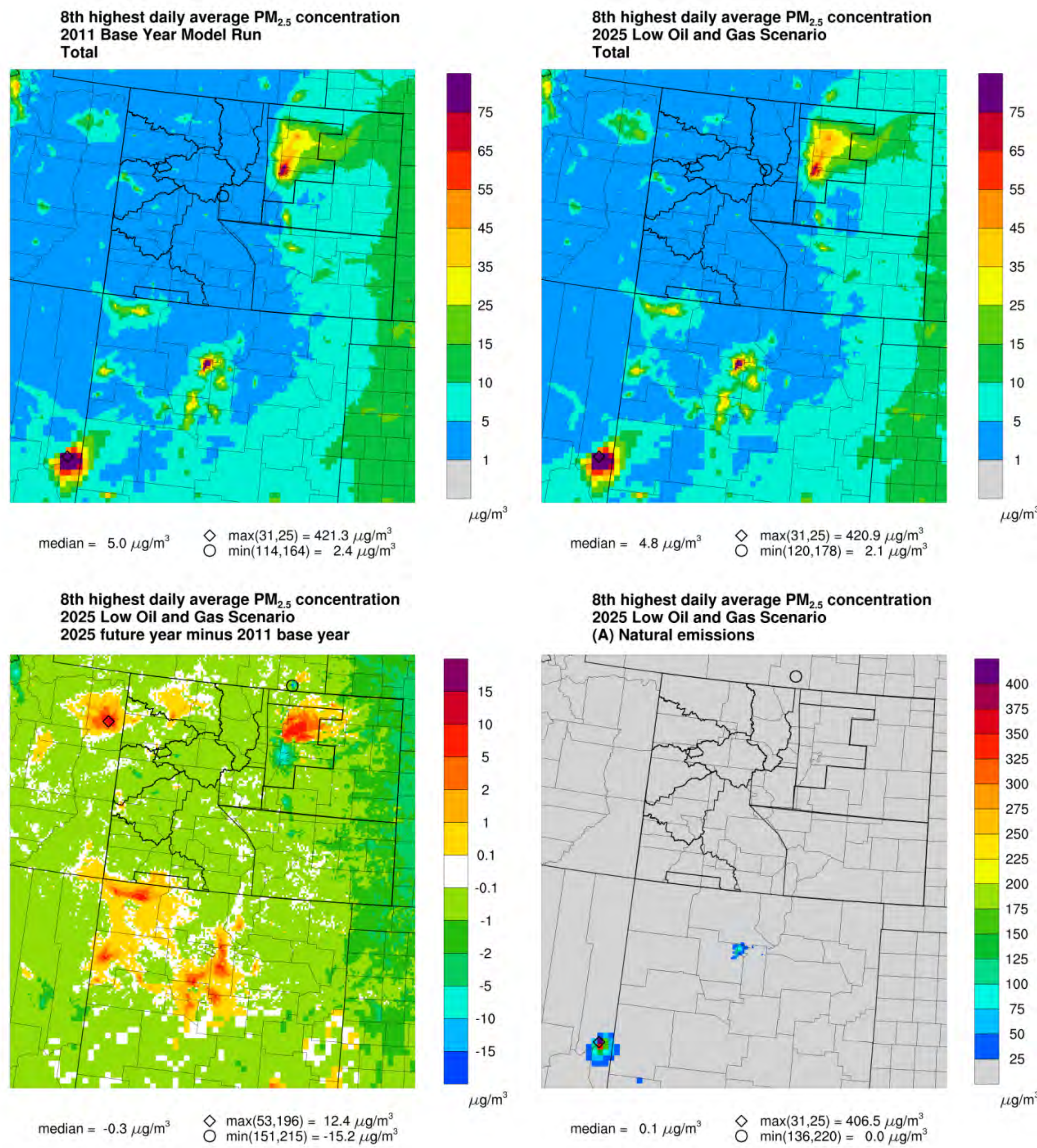

Figure 3-10. Eighth highest 24-hour $PM_{2.5}$ concentrations for the 2011 Base Case (top left), 2025 Low Development Scenario (top right), 2025 Low minus 2011 differences (bottom left) and Natural Emissions (bottom right).

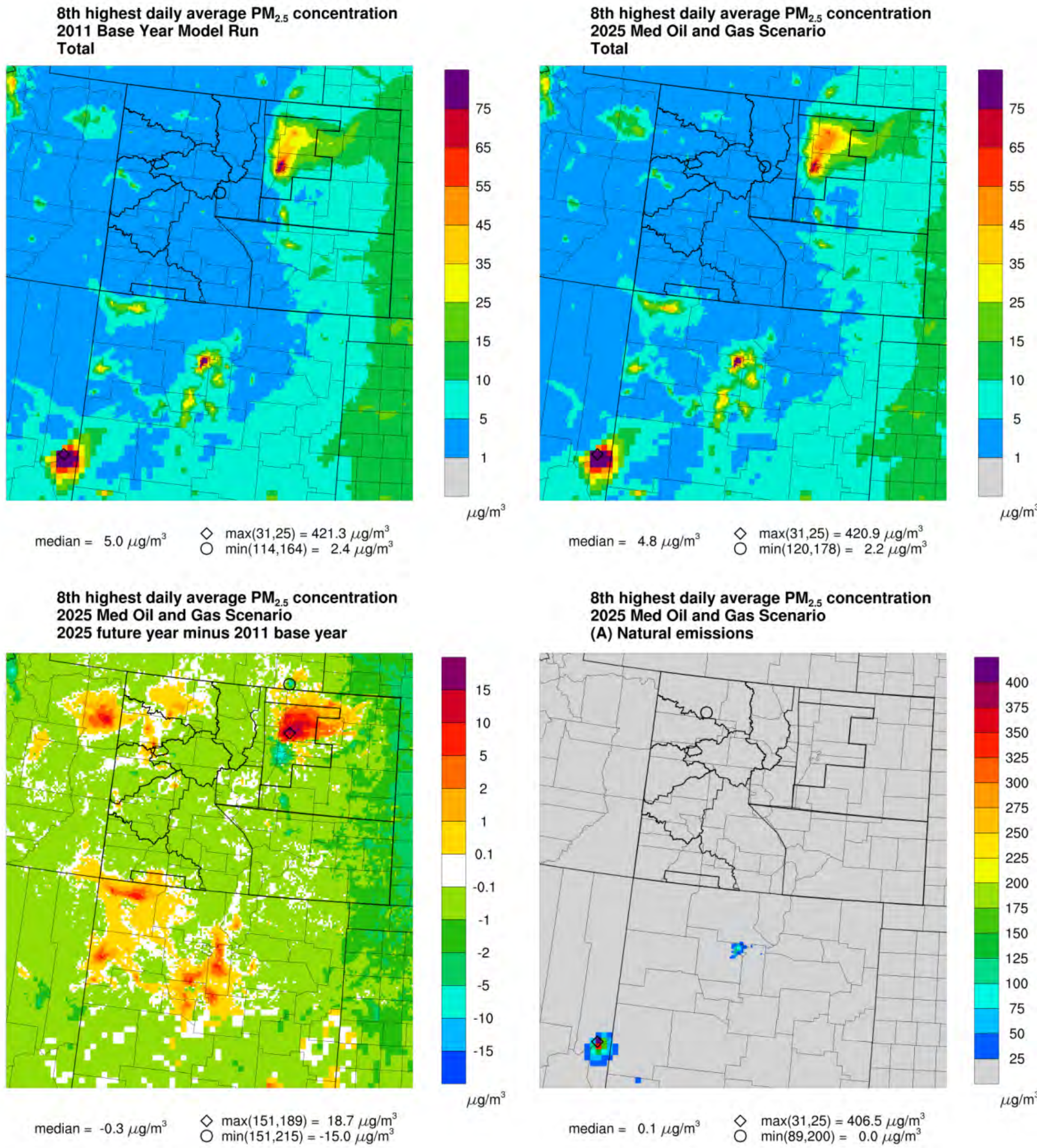

Figure 3-11. Eighth highest 24-hour $PM_{2.5}$ concentrations for the 2011 Base Case (top left), 2025 Medium Development Scenario (top right), 2025 Medium minus 2011 differences (bottom left) and Natural Emissions (bottom right).

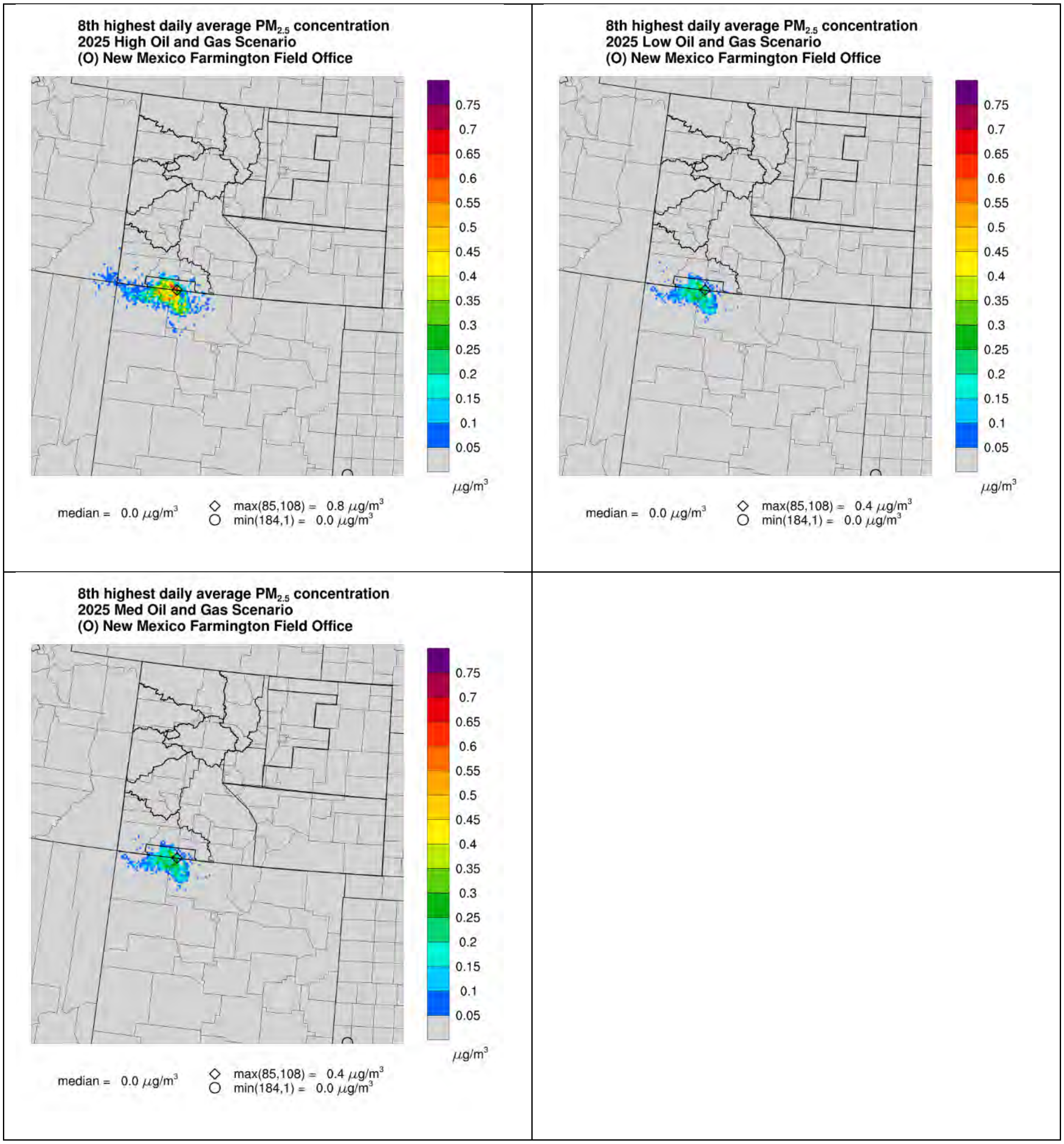

Figure 3-12. Contribution to 8th highest daily $PM_{2.5}$ concentrations due to emissions from New Mexico FFO for the 2025 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

3.3.2 Annual Average $PM_{2.5}$ NAAQS Analysis

Figure 3-13, Figure 3-14, and Figure 3-15 display the annual average $PM_{2.5}$ concentrations for the 2011 Base Case and 2025 emissions scenarios and their differences and the annual average $PM_{2.5}$ concentrations due to Natural Emissions concentration for the High, Low and Medium Development Scenarios, respectively. The highest annual average $PM_{2.5}$ concentration is about 23.5 µg/m^3 for the 2011 Base Case, and 21.1, 20.9, and 21.0 µg/m^3 in the 2025 High, Low, and Medium Development Scenarios. Compared to 2011, 2025 annual $PM_{2.5}$ concentrations are reduced in most of the domain, but increase in a number of regions, including near Denver, where about 10 µg/m^{3}of increase in annual $PM_{2.5}$ occurs for the High and Medium Development Scenarios.

Figure 3-16 shows the contribution of New Mexico FFO to annual average $PM_{2.5}$ concentrations in the three 2025 Development Scenarios. The peak 8th highest daily $PM_{2.5}$ concentrations are 0.3, 0.1 and 0.1 µg/m^3 in the 2025 High, Low and Medium Development Scenarios, respectively.

Table 3-5 reports maximum contributions to the annual average $PM_{2.5}$ concentrations for the Natural Source Group, total Source Groups and the New Mexico FFO Source Group for the 2025 High, Low and Medium Development Scenarios.

Table 3-5. Maximum contribution to the annual average $PM_{2.5}$ concentrations (µg/m^3) for each of the Natural Source Group, Total Source Groups and New Mexico FFO 2025 High, Low and Medium Development Scenarios.

Source Group	High (µg/m^3)	Low (µg/m^3)	Medium (µg/m^3)
Natural Emissions	17.4	17.4	17.4
New Mexico FFO	0.3	0.1	0.1
2011 Total	23.5	23.5	23.5
2025 Total	21.1	21.1	21.1

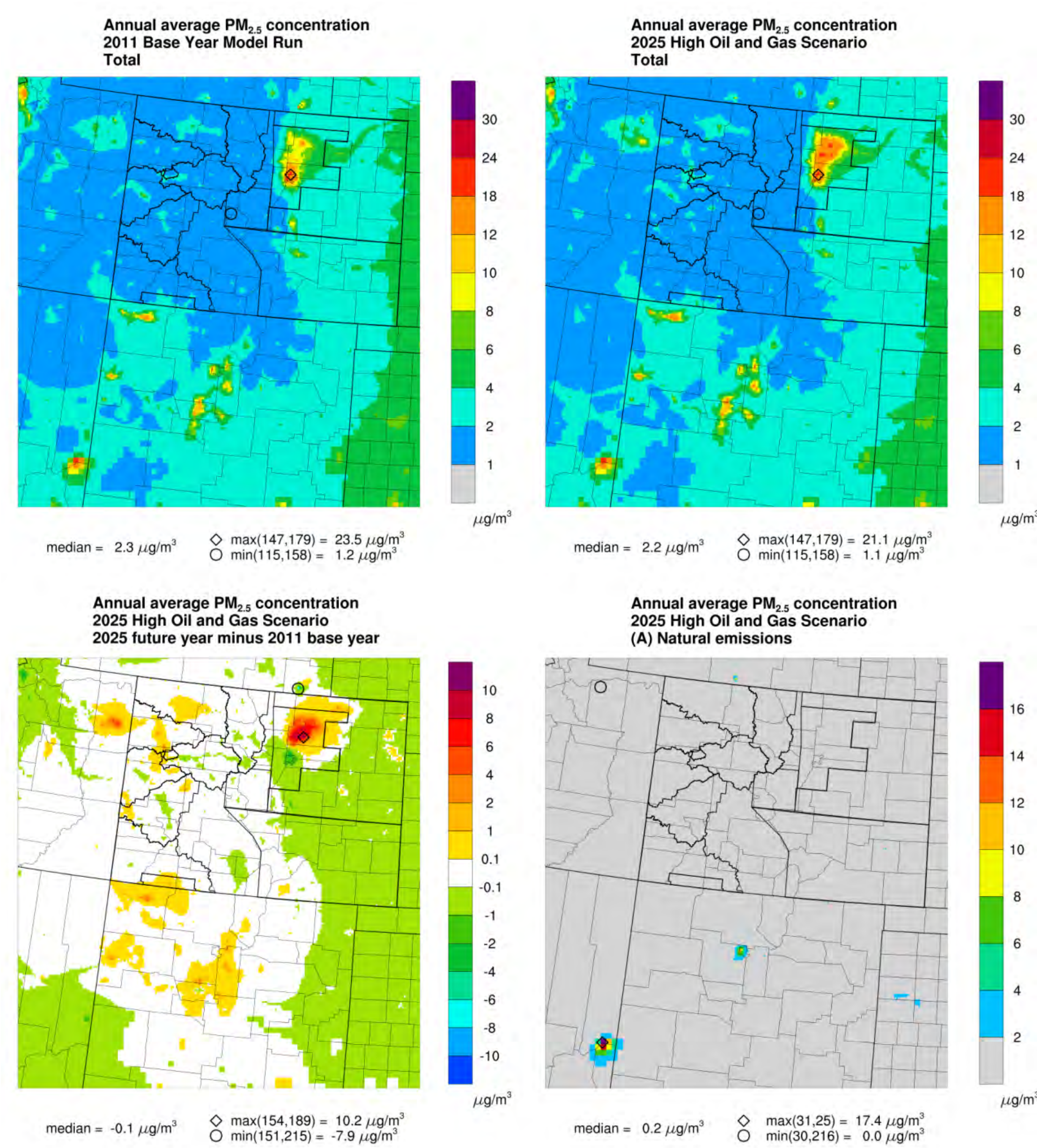

Figure 3-13. Annual average $PM_{2.5}$ concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 High minus 2011 differences (bottom left) and Natural Emissions (bottom right).

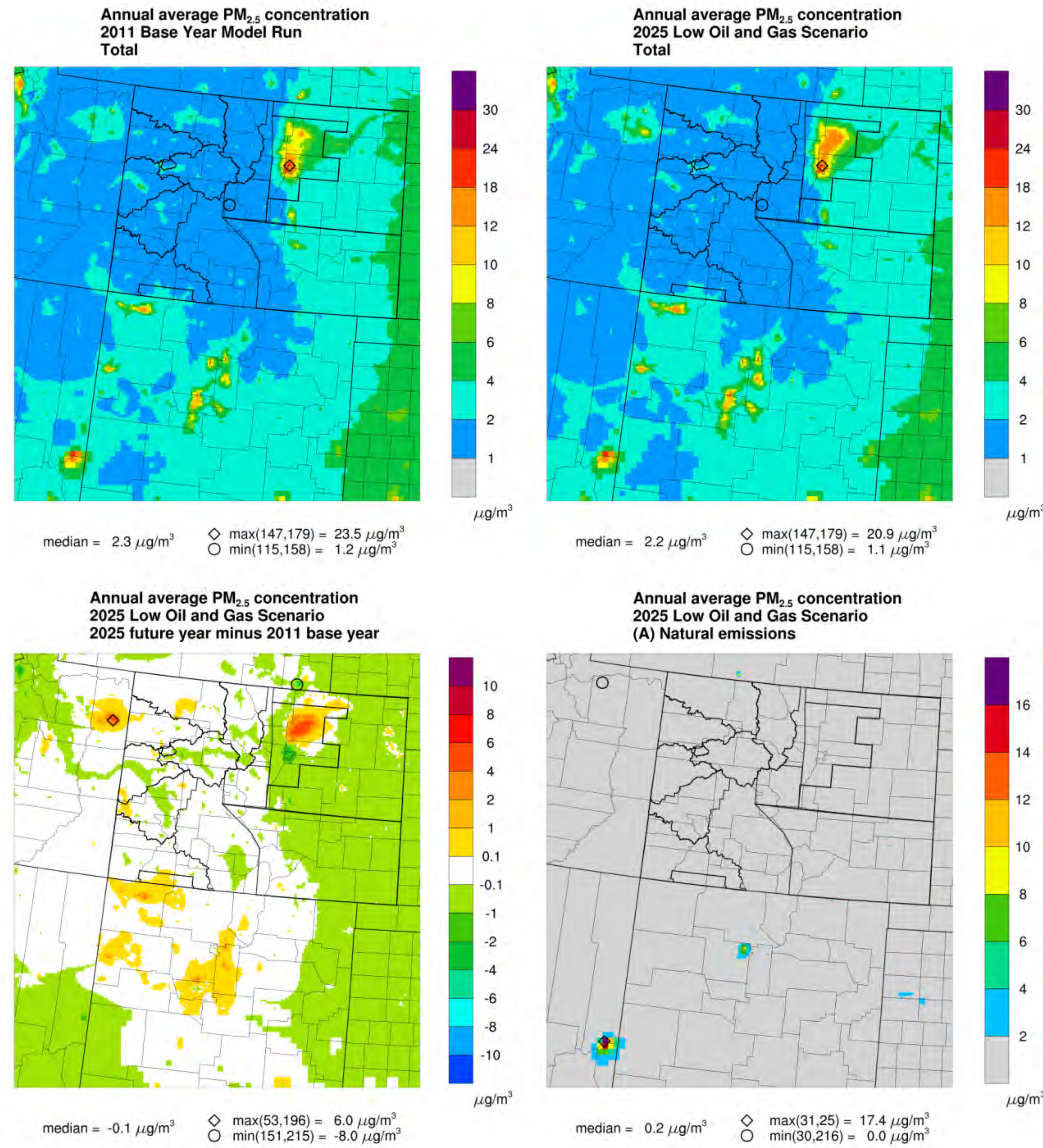

Figure 3-14. Annual average $PM_{2.5}$ concentrations for the 2011 Base Case (top left), 2025 Low Development Scenario (top right), 2025 Low minus 2011 differences (bottom left) and Natural Emissions (bottom right).

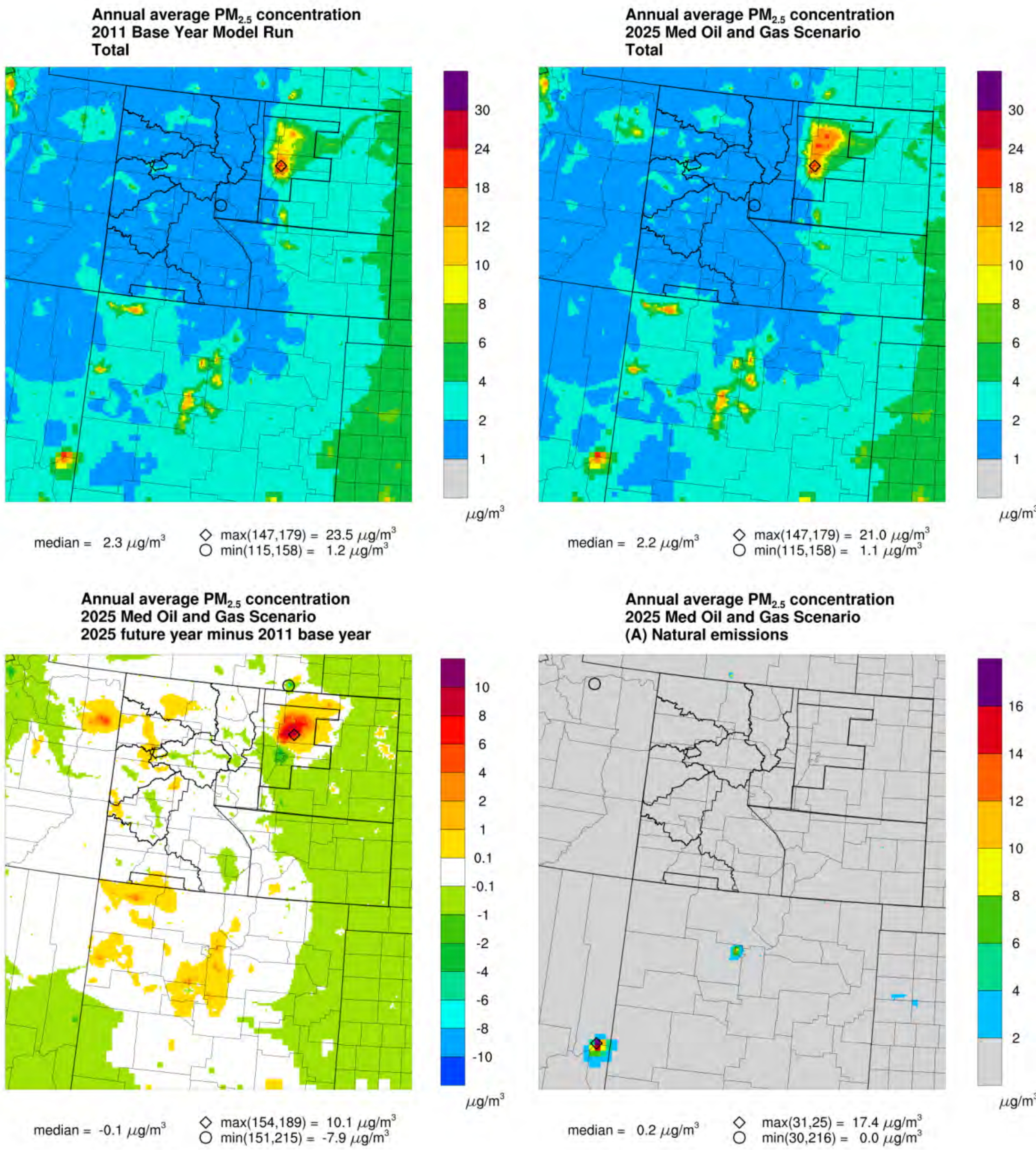

Figure 3-15. Annual average $PM_{2.5}$ concentrations for the 2011 Base Case (top left), 2025 Medium Development Scenario (top right), 2025 Medium minus 2011 differences (bottom left) and Natural Emissions (bottom right).

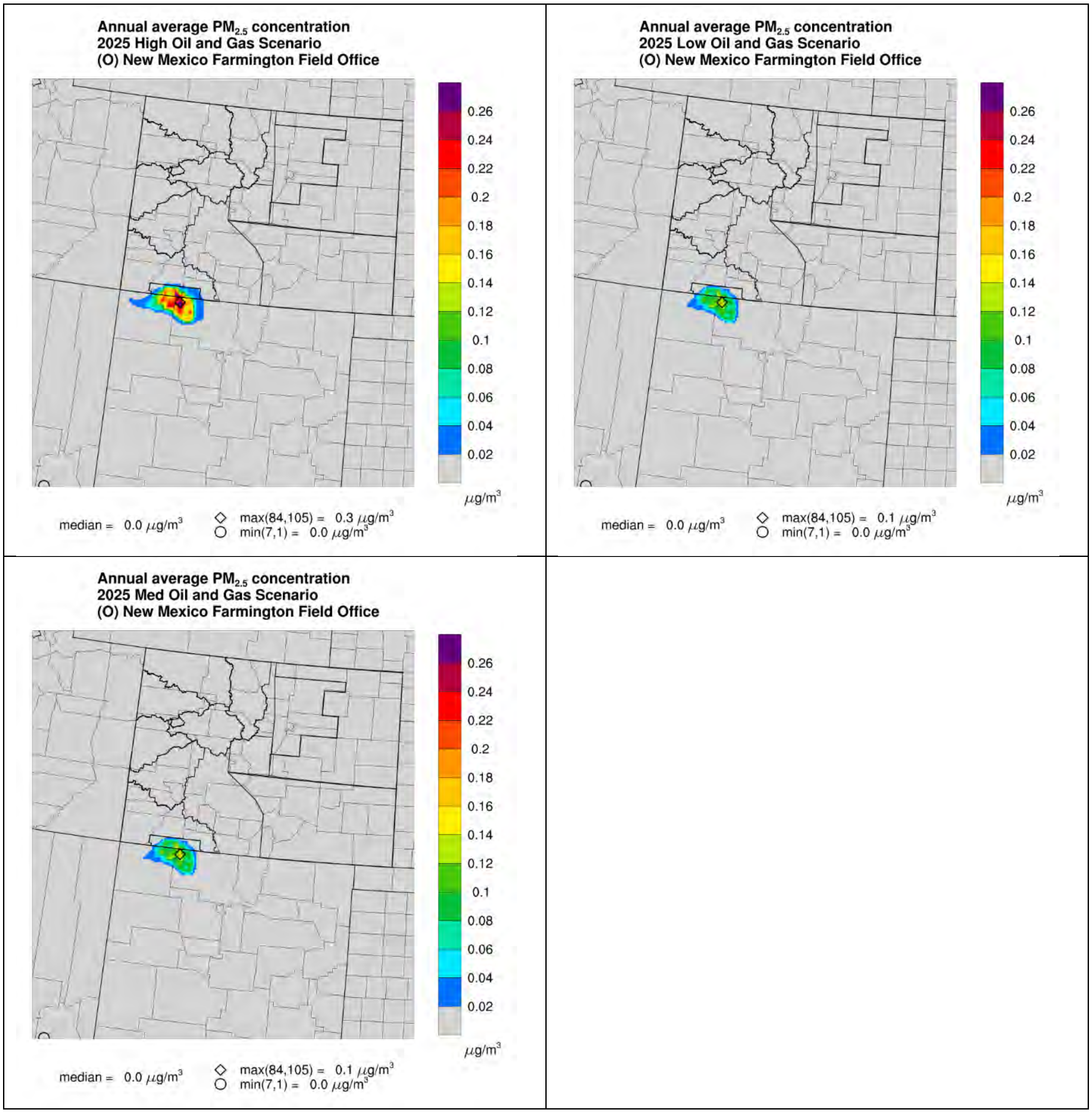

Figure 3-16. Contribution to annual average $PM_{2.5}$ from New Mexico FFO for the 2025 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

3.4 PM_{10} NAAQS Analysis

Figure 3-17 displays the 2025 High Development Scenario modeling results for 24-hour PM_{10} that can be compared to the 150 µg/m^3 24-hour PM_{10} NAAQS. Much of the discussion on 24-hour $PM_{2.5}$ also holds for 24-hour PM_{10}, although there appear to be more exceedances of the 24-hour PM_{10} NAAQS. Extremely large highest second high PM_{10} concentrations occur in the 2011 and 2025 emissions scenarios that exceed 1,000 µg/m^3 (Figure 3-17, top panels), which are largely due to natural emissions from wild fires near the AZ/NM boarder.

Figure 3-18 repeats the 2011 Base, and 2025 High Development plots on the top panels and contrasts with the Low and Medium Development Scenario results on the bottom plots. Figure 3-19 presents the difference between the 2011 Base and the three 2025 Development Scenarios.

Figure 3-20 shows the contributions of New Mexico FFO to 2nd highest daily PM_{10} concentrations in the three 2025 scenarios. The maximum contributions to the 2nd highest 24-hour PM_{10} concentrations from the New Mexico FFO are 2.7, 1.3 and 1.1 µg/m^3 in the 2025 High, Low and Medium Development Scenarios, respectively. The low scenario and high scenario have the same control assumptions, but different oil and gas activity. The medium scenario has the same level of oil and gas activity as the high scenario, but with additional mitigation (i.e., control). Emission reductions from the high scenario to the medium scenario resulting from emission controls may be more substantial than emission reductions from the high scenario to the low scenario resulting from different activity levels.

Table 3-6 reports the maximum contributions to the 2nd highest daily average PM_{10} concentrations for the Natural Source Group, total Source Groups and the New Mexico FFO Source Group for the 2025 High, Low and Medium Development Scenarios. Note that the maximum contributions do not vary between the Development Scenarios for the 2025 Total contributions (and 2011 Base) because they are at regions of fire impacts which occurred for all three Development Scenarios.

Table 3-6. Maximum contribution to the 2nd highest daily average $PM_{2.5}$ concentrations (µg/m^3) for each of the Natural Source Group, Total Source Groups and New Mexico FFO 2025 High, Low and Medium Development Scenarios. NAAQS = 150 µg/m^3.

Source Group	High (µg/m^3)	Low (µg/m^3)	Medium (µg/m^3)
Natural Emissions	1030.6	1030.6	1030.6
New Mexico FFO	2.7	1.3	1.1
2011 Total	1045.2	1045.2	1045.2
2025 Total	1045.2	1045.2	1045.2

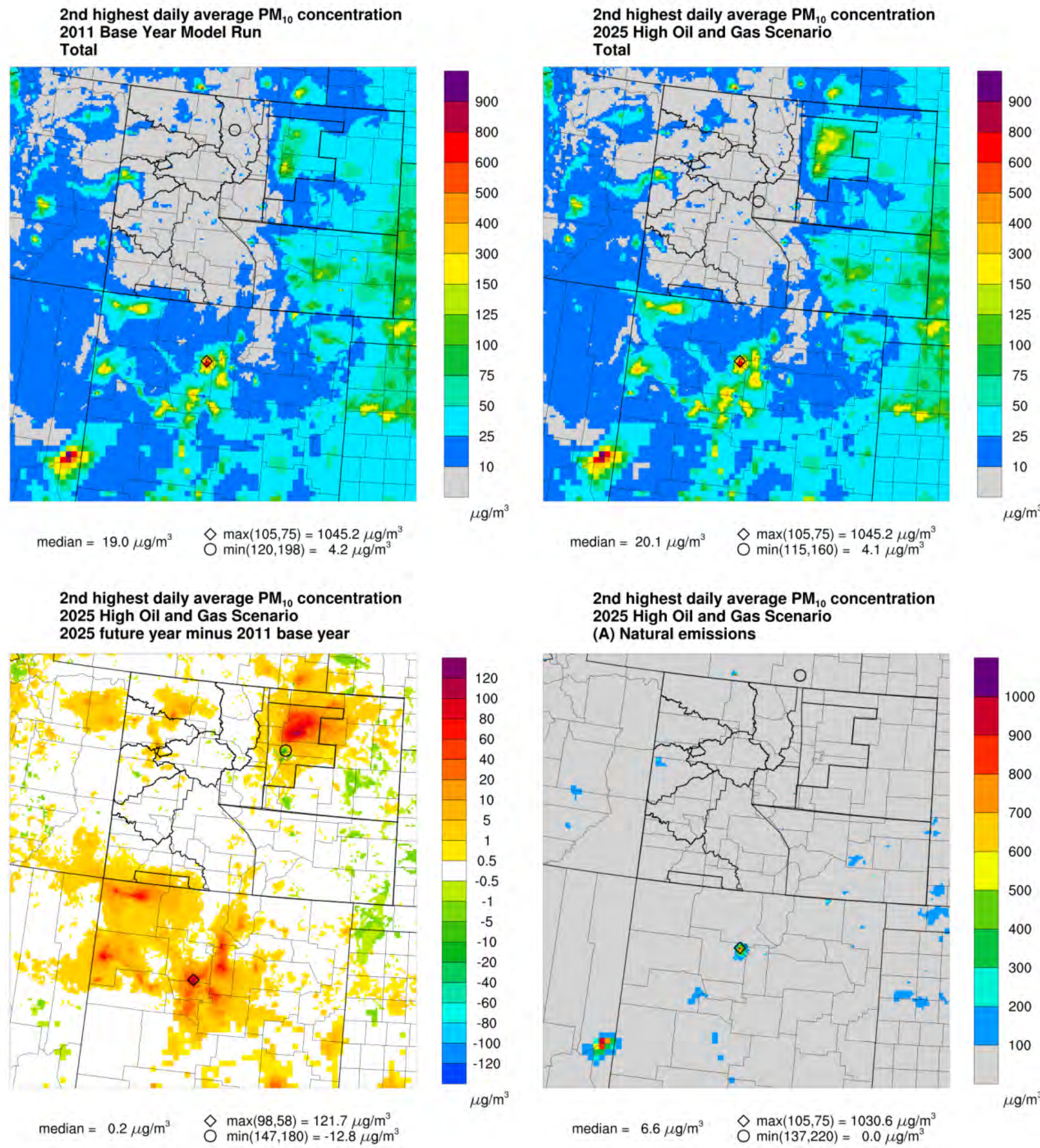

Figure 3-17. Second highest 24-hour average PM_{10} concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 minus 2011 differences (bottom left) and Natural Emissions (bottom right).

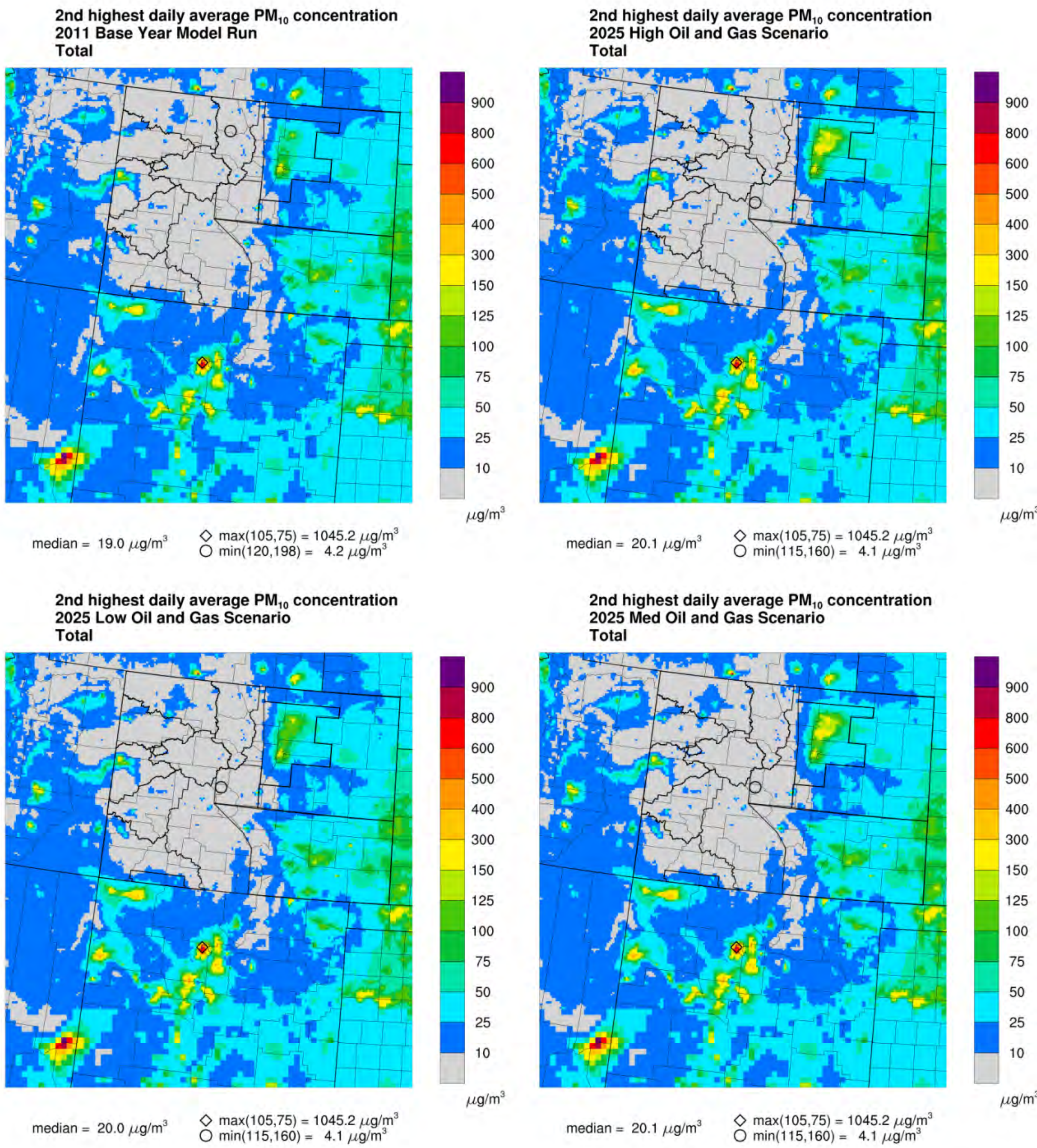

Figure 3-18. Second highest 24-hour average PM_{10} concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 Low Development Scenario (bottom left) and Medium Development Scenario (bottom right).

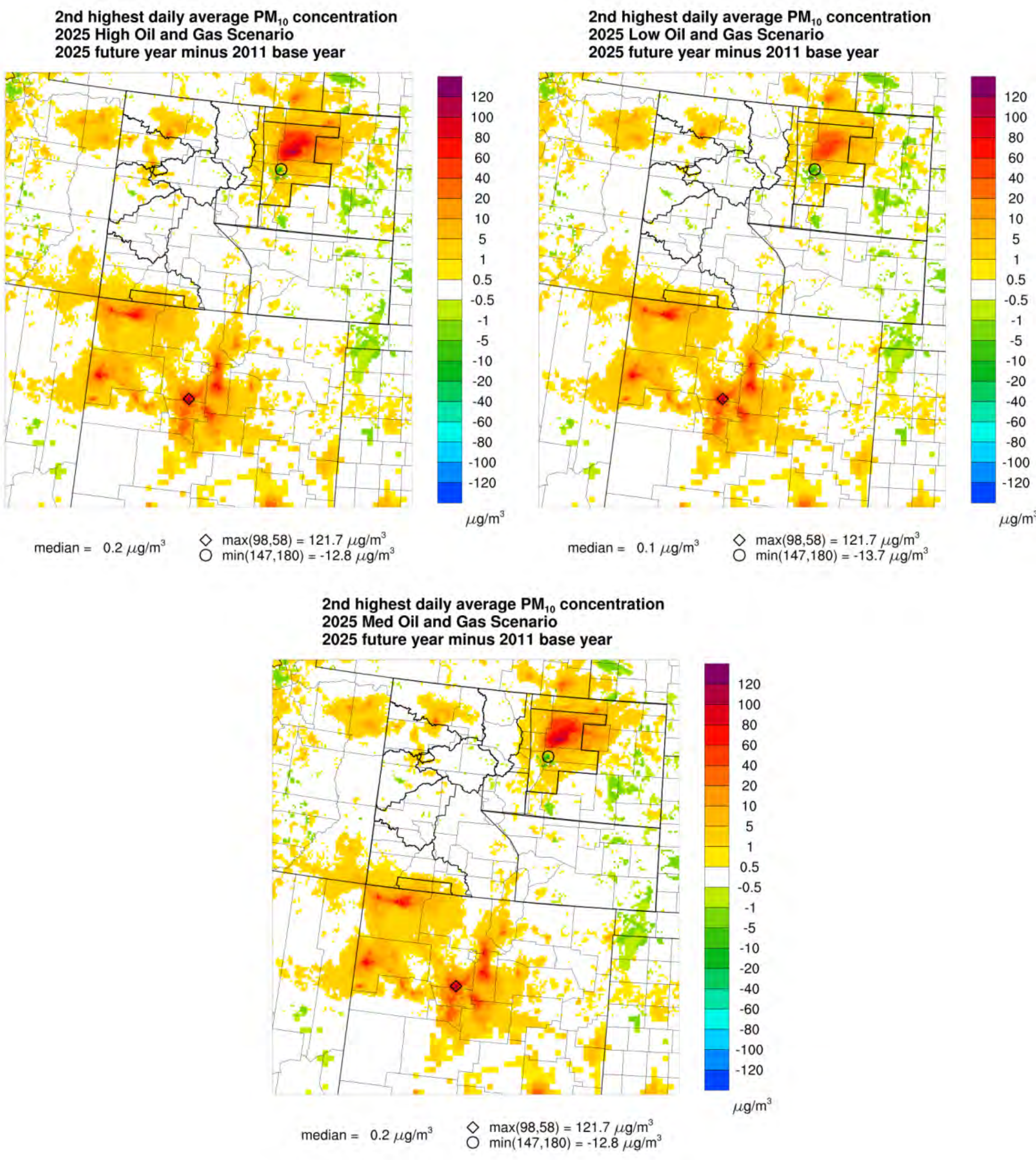

Figure 3-19. Second highest 24-hour average PM_{10} concentrations differences for: 2011 Base Case minus 2025 High Development Scenario (top left), 2011 Base Case minus 2025 Low Development (top right), 2011 Base Case minus 2025 Medium Development (bottom).

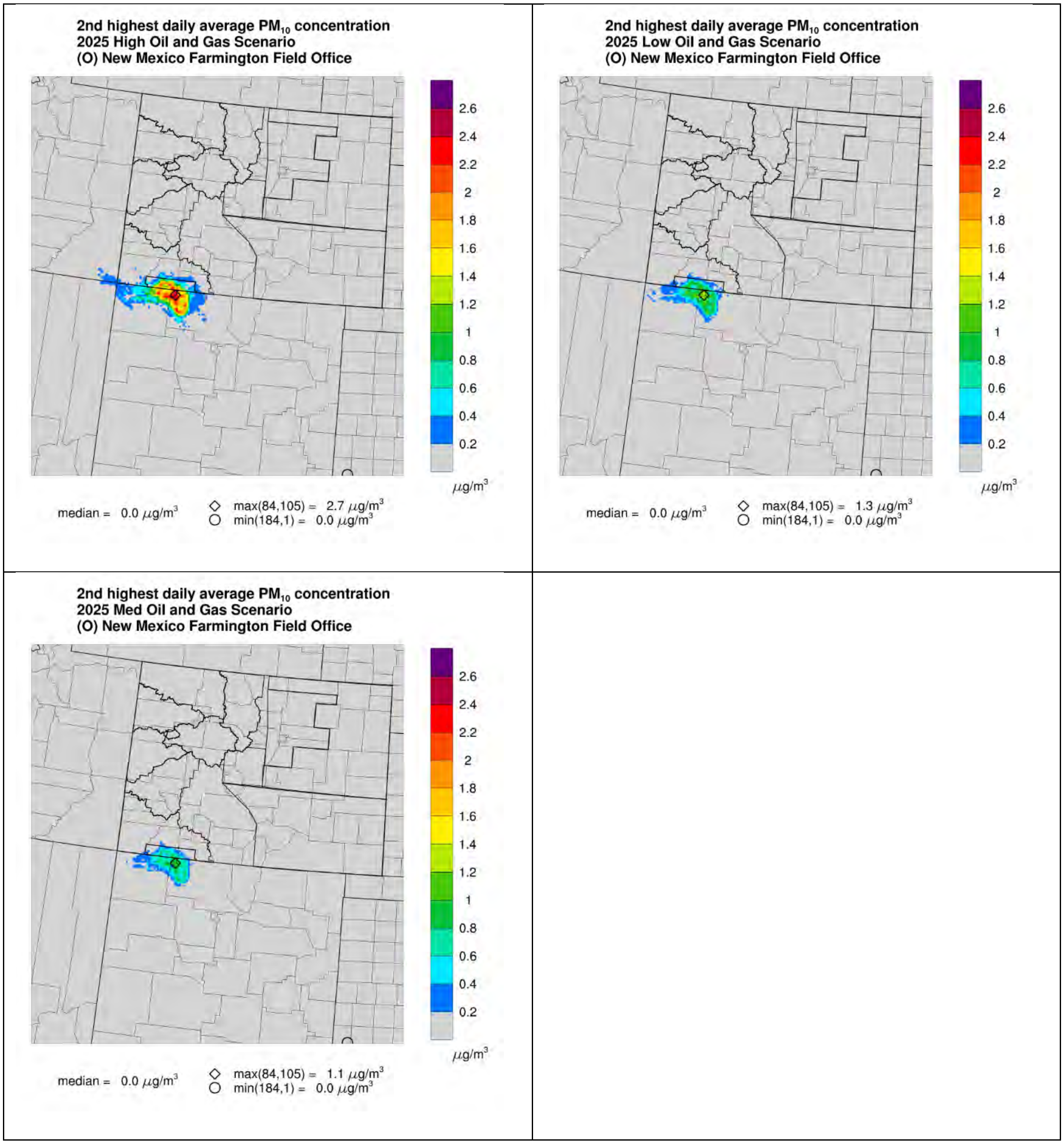

Figure 3-20. Contribution to second highest daily average PM_{10} concentrations from New Mexico FFO for the 2025 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

3.5 SO_2 NAAQS Analysis

The 2011 Base Case and 2025 High Development Scenario, their differences and contributions of Natural Emissions to 1-hour, 3-hour, 24-hour average and annual average SO_2 concentrations are shown in Figure 3-21, Figure 3-22, Figure 3-23, and Figure 3-24, respectively. The 1-hour SO_2 NAAQS is 75 ppb and it is exceeded when the colors in Figure 5-18 are yellow or hotter. Natural emissions from wild fires are the primary cause for the two exceeding areas in Arizona and New Mexico. 1-hour SO_2 is overall below 30 ppb in most places and shows reduction from the 2011 base year to the 2025 High Development Scenario throughout most of the domain. Similarly, 3-hour, 24-hour and annual average SO_2 are all well below the corresponding NAAQS/CAAQS/NMAAQS, except for small areas affected by extreme wild fires, and all of them show a reduction from the 2011 base year to the 2025 High Development Scenario throughout most of the domain.

Figure 3-25 shows that the New Mexico FFO contribution to 1-hr, 3-hr, 24-hr and annual average SO_2 concentrations. New Mexico FFO contributions for all metrics are less than less than 0.1 ppb.

Since there are no NAAQS exceedances except due to natural emissions and the New Mexico FFO contributions, only the High Development Scenario results are presented, and these serve as an upper bound for the Low and Medium Development Scenario Results.

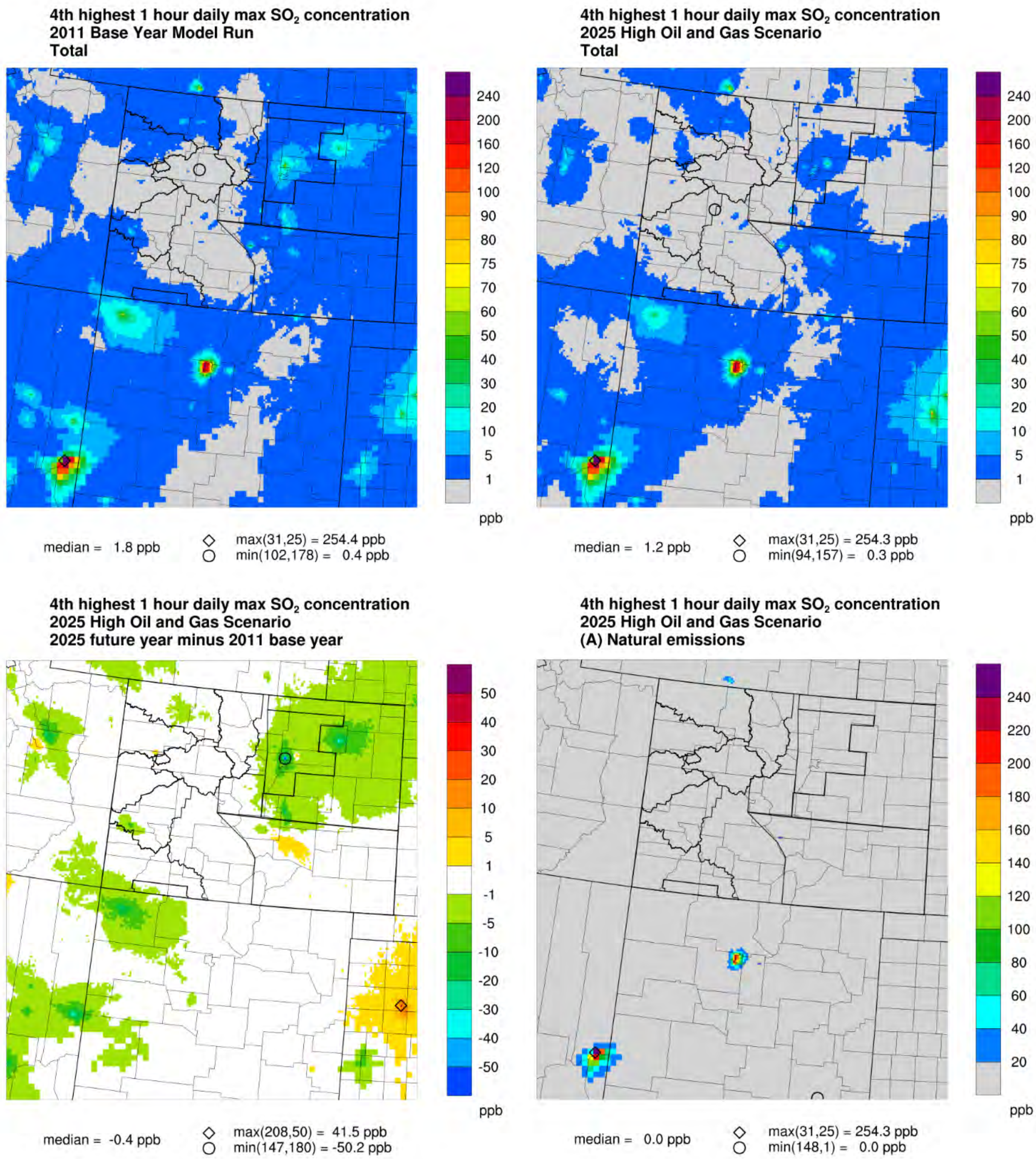

Figure 3-21. Fourth highest (99th percentile) daily maximum 1-hour average SO2 concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 minus 2011 differences (bottom left) and Natural Emissions (bottom right).

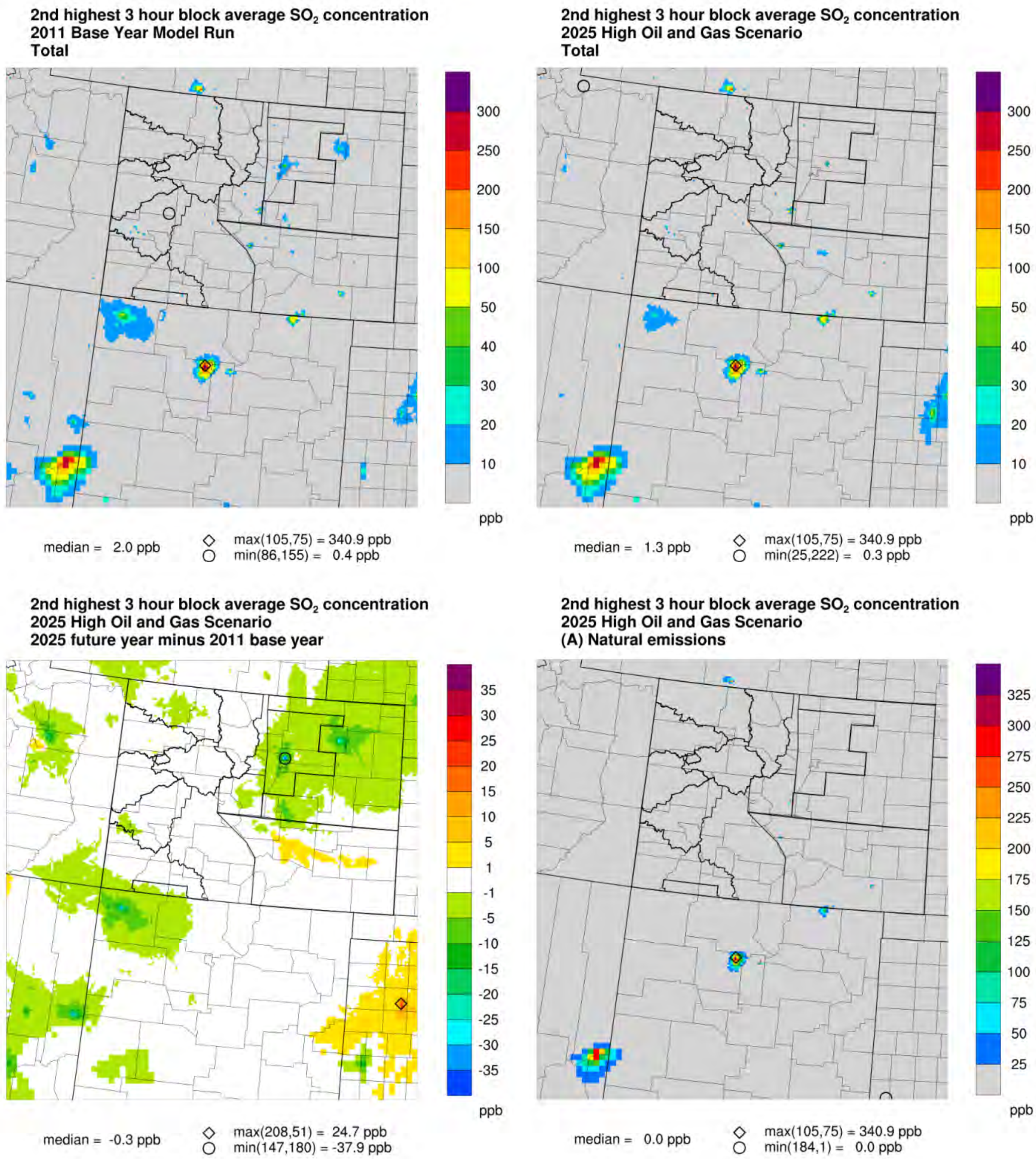

Figure 3-22. Second highest 3-hour average SO_2 concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 minus 2011 differences (bottom left) and Natural Emissions (bottom right).

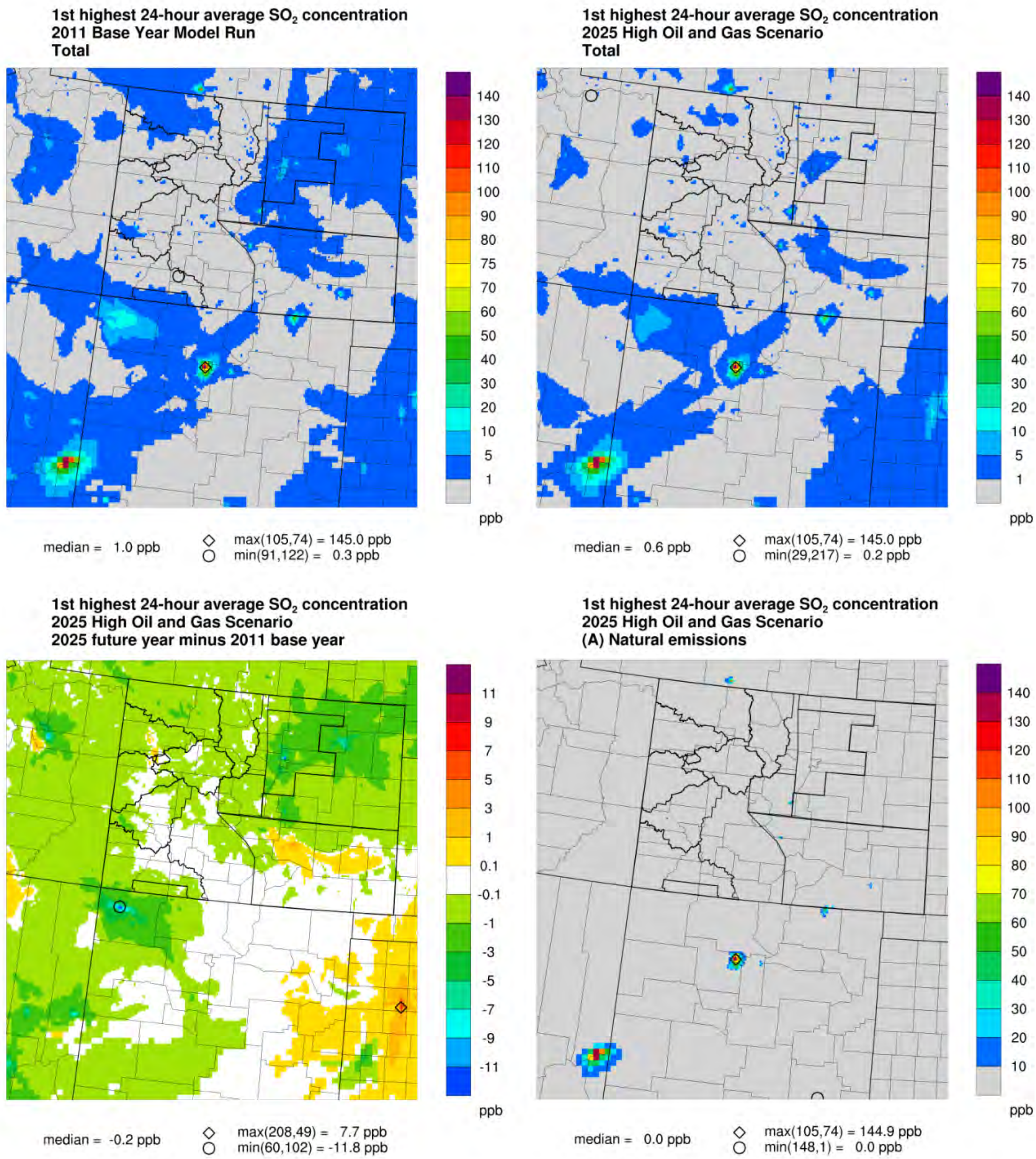

Figure 3-23. 24-hour average SO_2 concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 minus 2011 differences (bottom left) and Natural Emissions (bottom right).

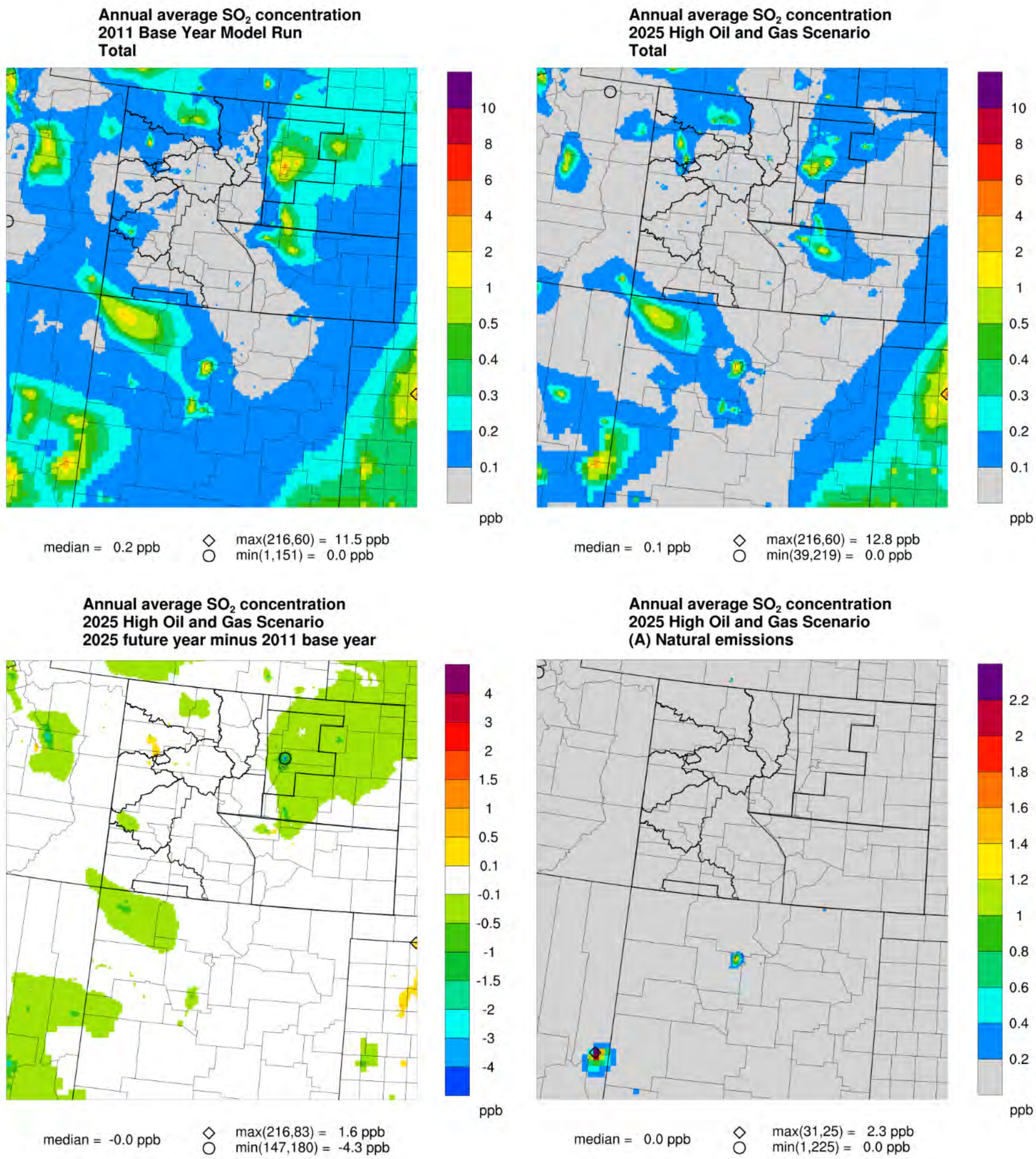

Figure 3-24. Annual average SO_2 concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 minus 2011 differences (bottom left) and Natural Emissions (bottom right).

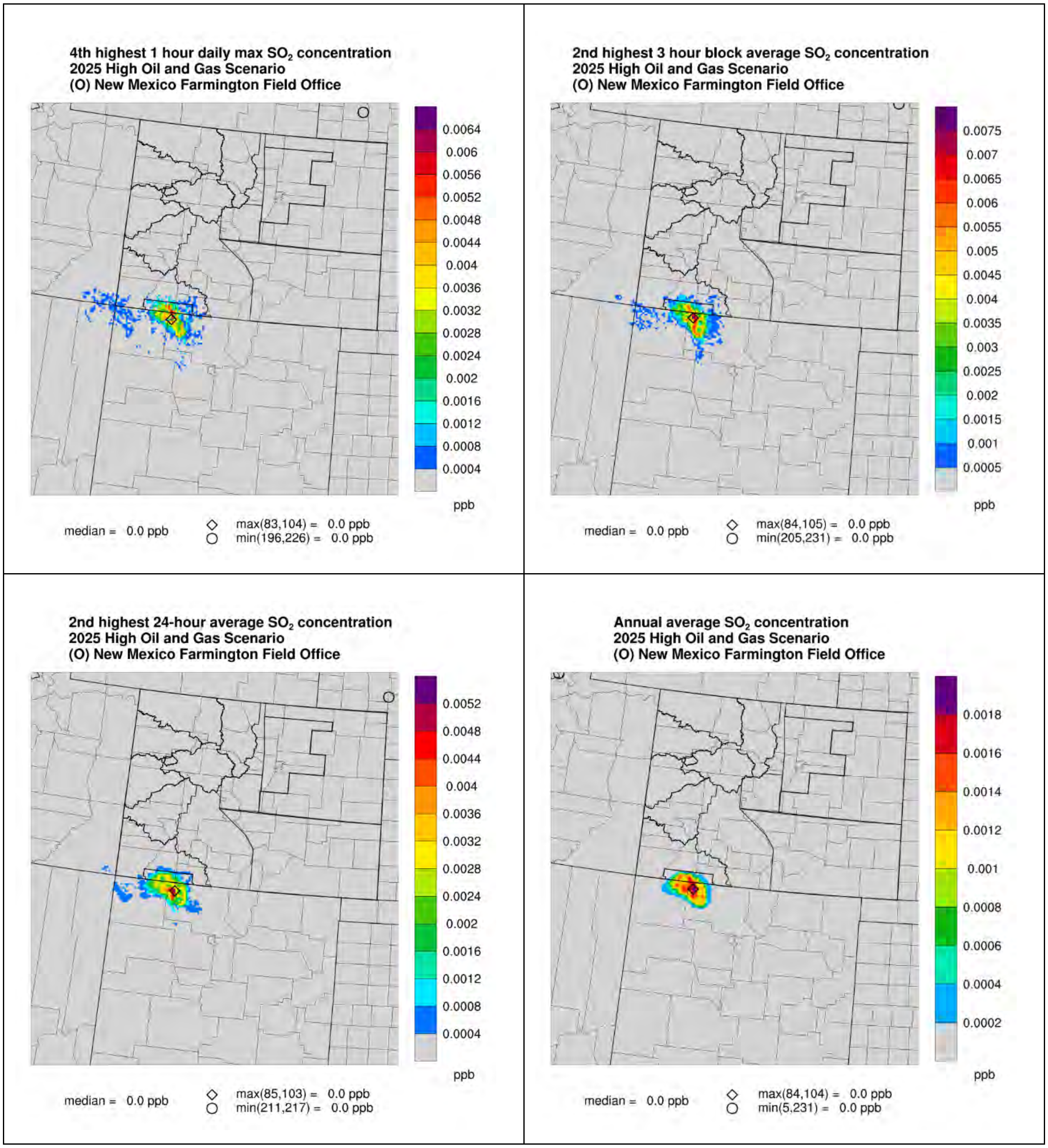

Figure 3-25. Contribution to 1-hr (top left), 3-hr (top right), 24-hr (bottom left) and annual (bottom right) SO_2 concentrations due to emissions from New Mexico FFO High Development Scenario.

3.6 NO_2 NAAQS Analysis

3.6.1 1-Hr NO_2 NAQS Analysis

Figure 3-26 displays spatial maps of the 98th percentile daily maximum 1-hour NO_2 concentrations for the 2011 Base Case and 2025 High, Low and Medium Development Scenarios with the differences in NO_2 concentrations between the 2025 emissions scenarios and the 2011 Base Case shown in Figure 3-27. The 1-hour NO_2 NAAQS is 188 µg/m^3 (100 ppb) and the tile plots in Figure 3-26 have a cut-point at 100 ppb. In all four scenarios, the highest 1-hour NO_2 concentration occurs near the AZ/NM border and is above the NAAQS. This NO_2 exceedance is due to wildfires and is present in the 2011 Base Case and 2025 scenarios since wildfires were assumed to be unchanged.

The differences in 1-hour NO_2 concentrations between the 2011 and 2025 emission scenarios (Figure 3-27) indicate increases at various regions throughout the domain including large increases in northern, as well as eastern Arizona and New Mexico. The largest increases are 64.1, 54.2, and 64.0 ppb for the High, Low, Medium Scenarios, respectively.

Figure 3-28 shows the contributions from New Mexico FFO to the 98th percentile daily maximum 1-hour NO_2 concentrations for each of the High, Low and Medium Development Scenarios, respectively. The maximum contributions for the High, Medium and Low Development Scenarios are 5.8, 3.2 and 3.0 ppb, respectively.

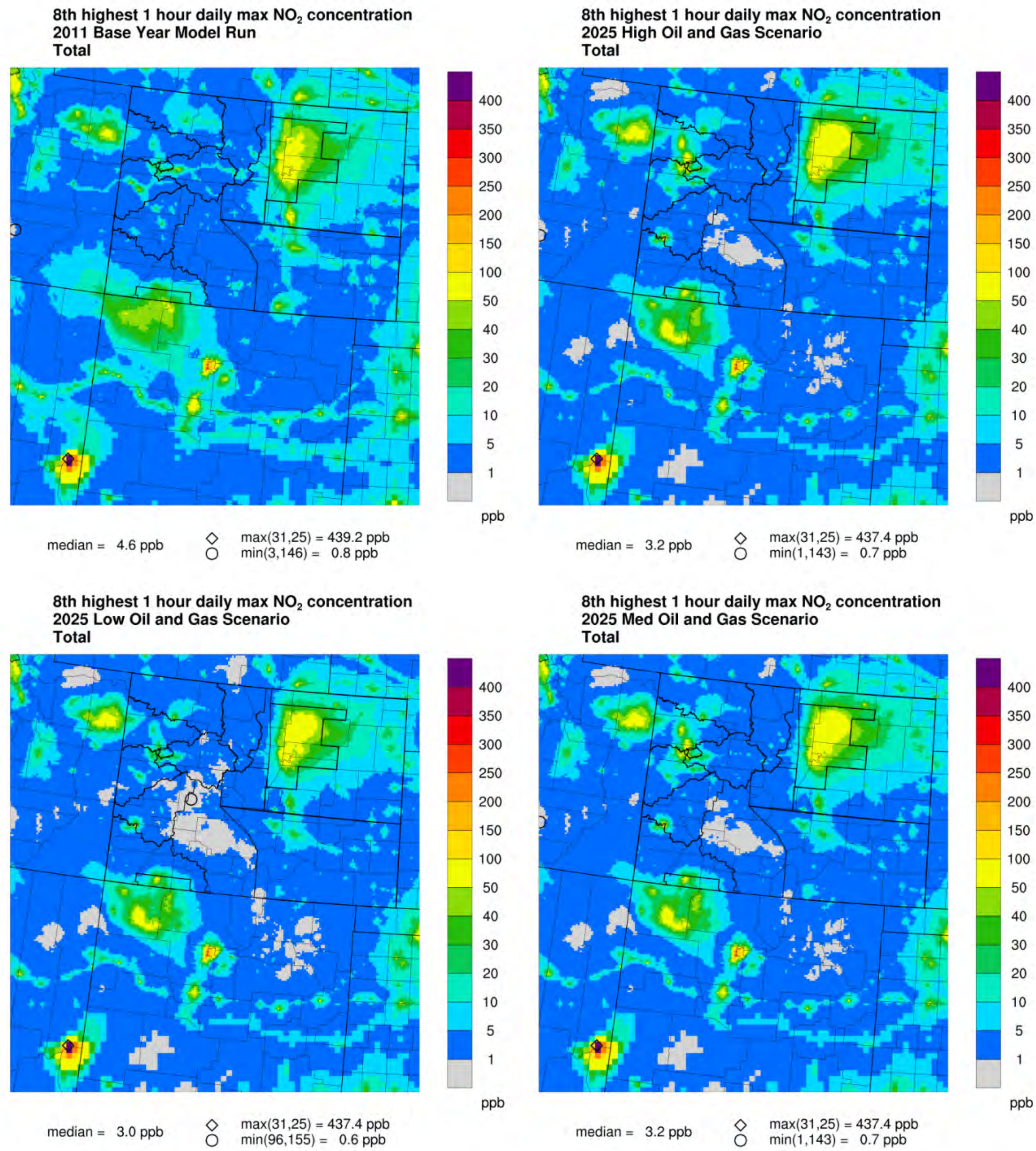

Figure 3-26. Eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 Low Development Scenario (bottom left) and 2025 Medium Development Scenario (bottom right).

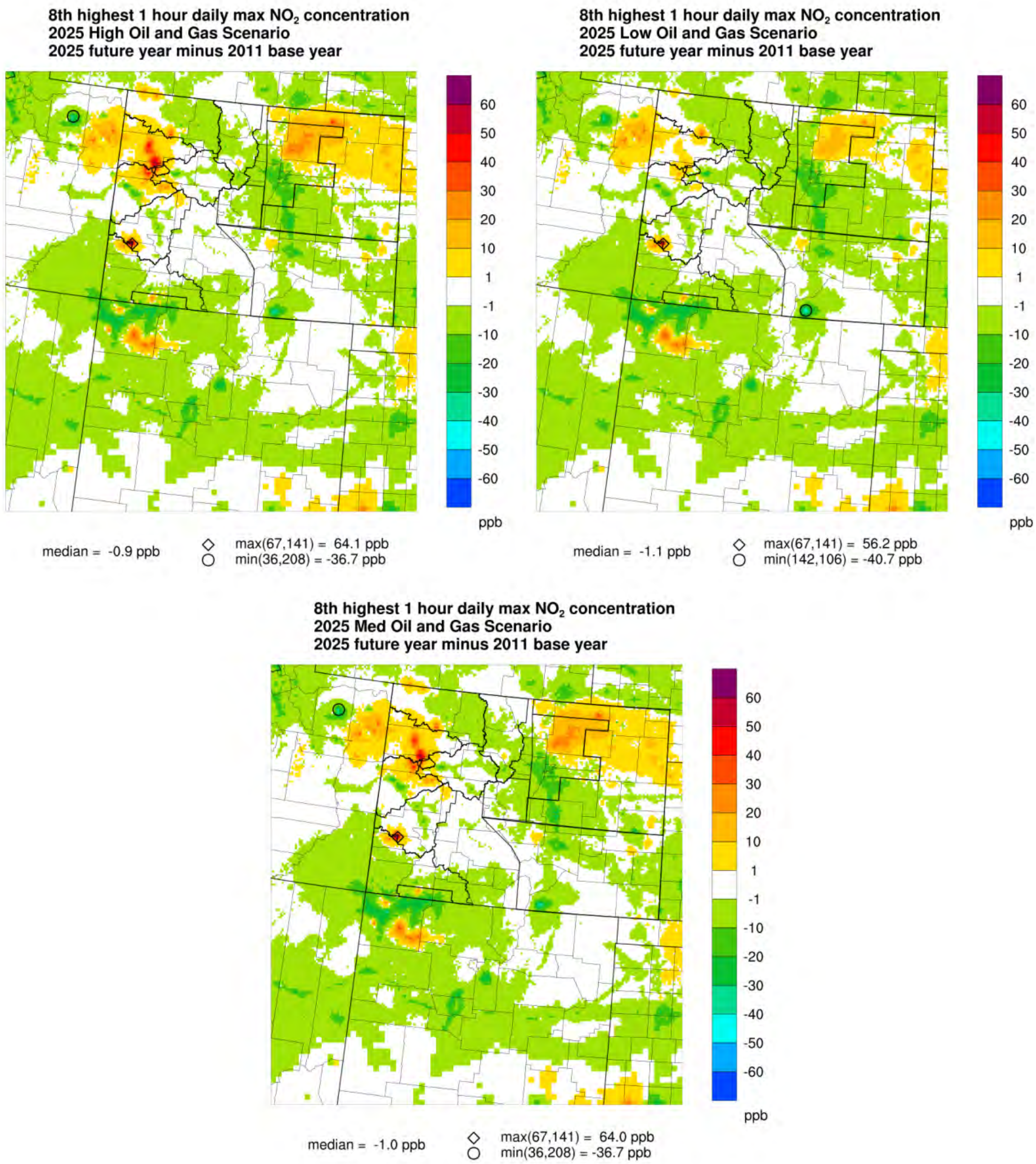

Figure 3-27. Differences in eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations between the 2025 emission scenarios and the 2011 Base Case for the 2025 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

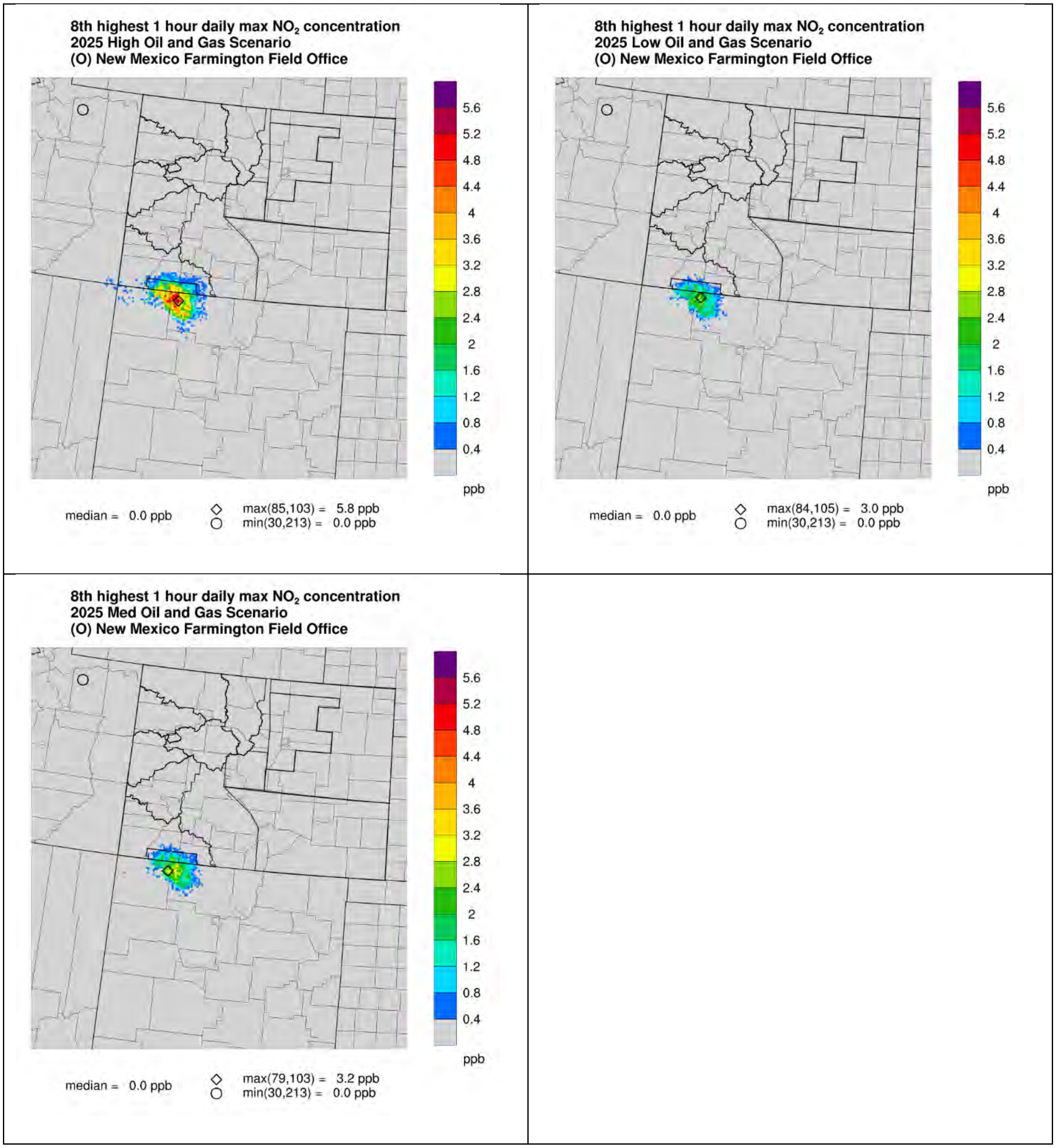

Figure 3-28. Contributions from New Mexico FFO to the eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations in the 2025 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

3.6.2 Annual Average NO_2 NAAQS Analysis

Figure 3-29 displays spatial maps of the annual average NO_2 concentrations for the 2011 Base Case and 2025 High, Low and Medium Development Scenarios with the differences in NO_2 concentrations between the 2025 emissions scenarios and the 2011 Base Case shown in Figure 3-30.The annual NO_2 NAAQS is 100 µg/m^3 (53 ppb) and Figure 3-29 shows no exceedances of the NAAQS.

Figure 3-31 shows the contributions from New Mexico FFO to the annual average NO_2 concentrations for each of the High, Low and Medium Development Scenarios, respectively. The maximum contributions for the High, Low, and Medium Development Scenarios are 1.5, 0.8 and 0.9 ppb, respectively.

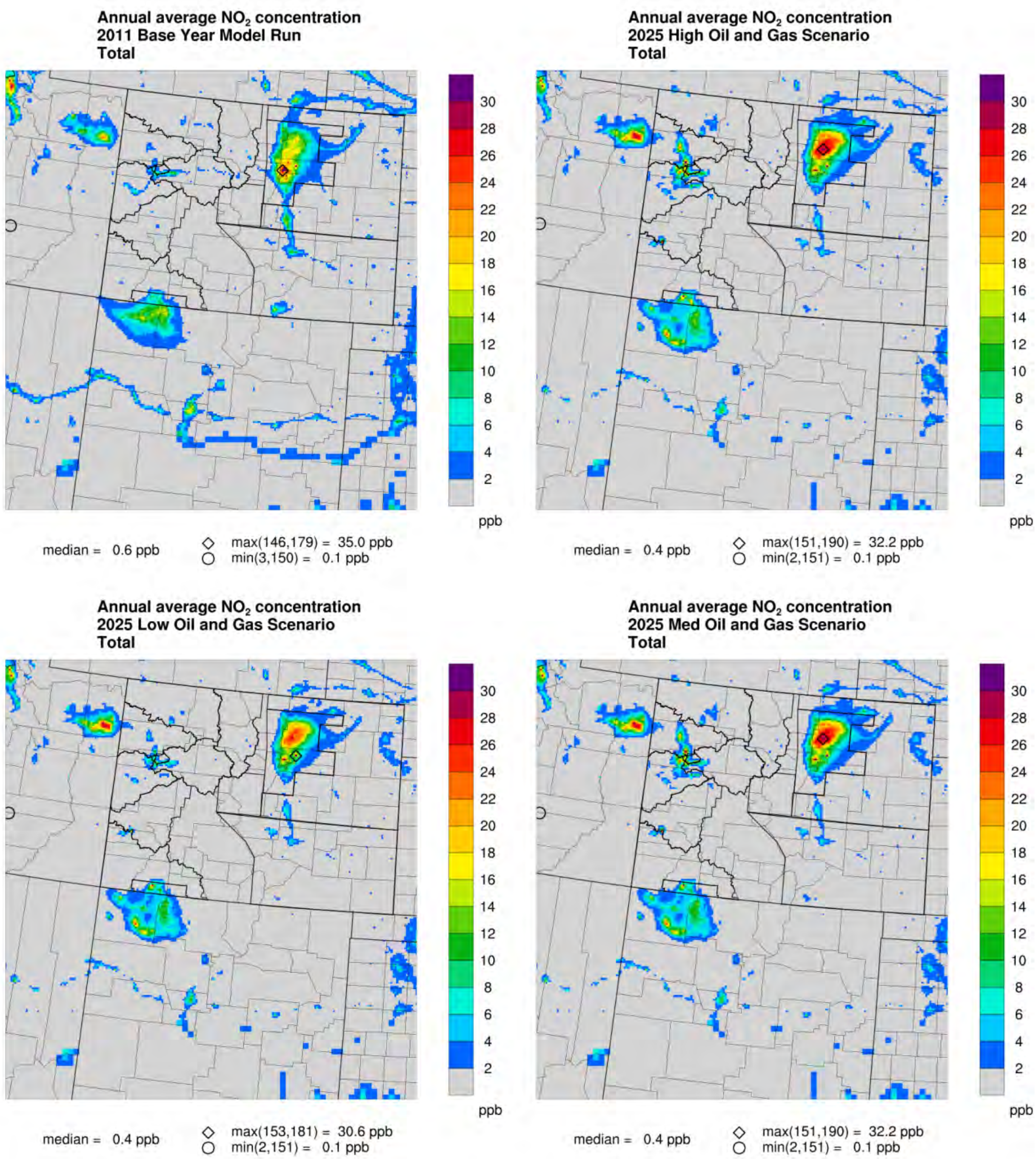

Figure 3-29. Annual average NO_2 concentrations for the 2011 Base Case (top left), 2025 High Development Scenario (top right), 2025 Low Development Scenario (bottom left) and 2025 Medium Development Scenario (bottom right).

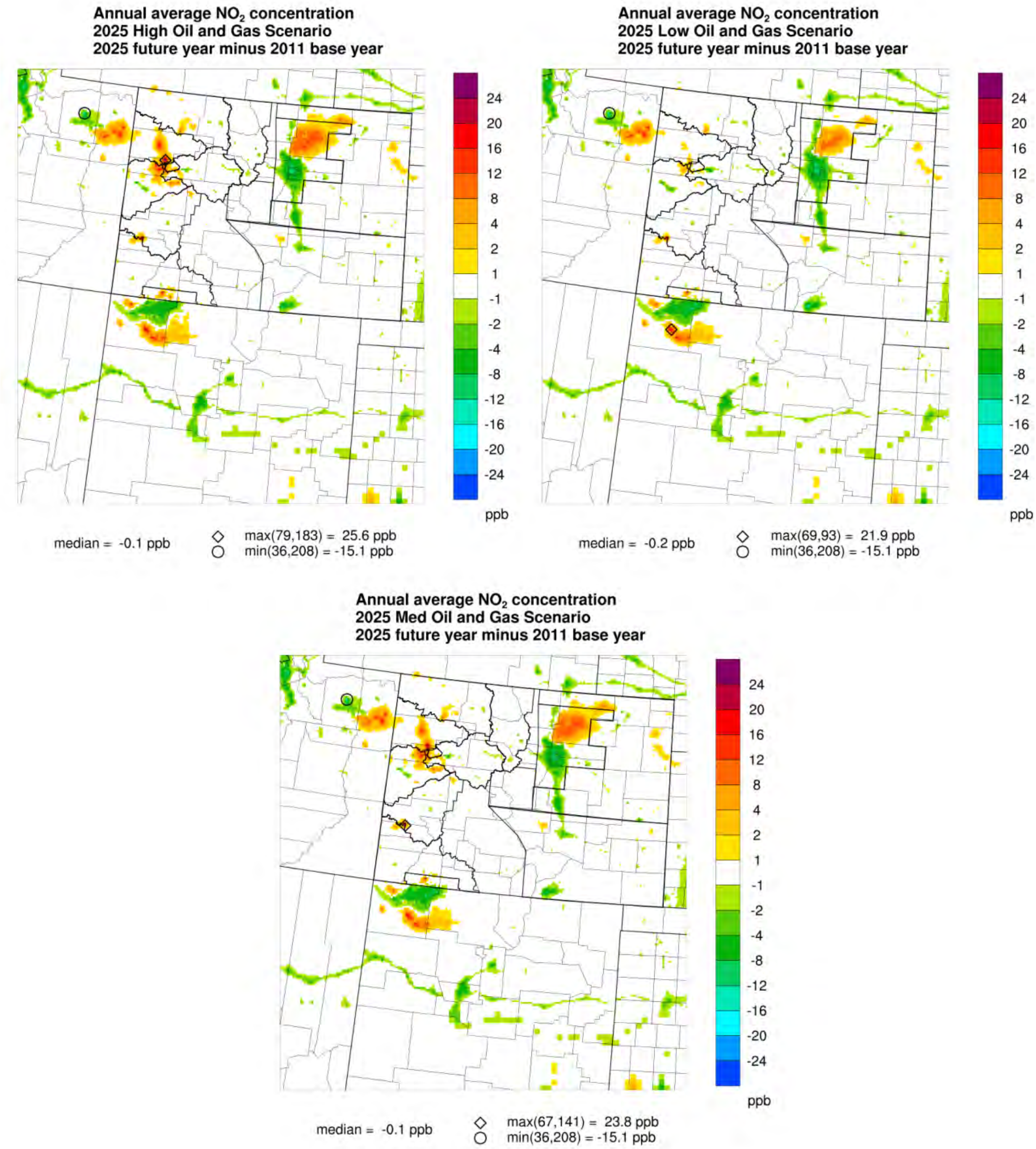

Figure 3-30. Differences in annual average NO_2 concentrations between the 2025 emission scenarios and the 2011 Base Case for the 2025 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

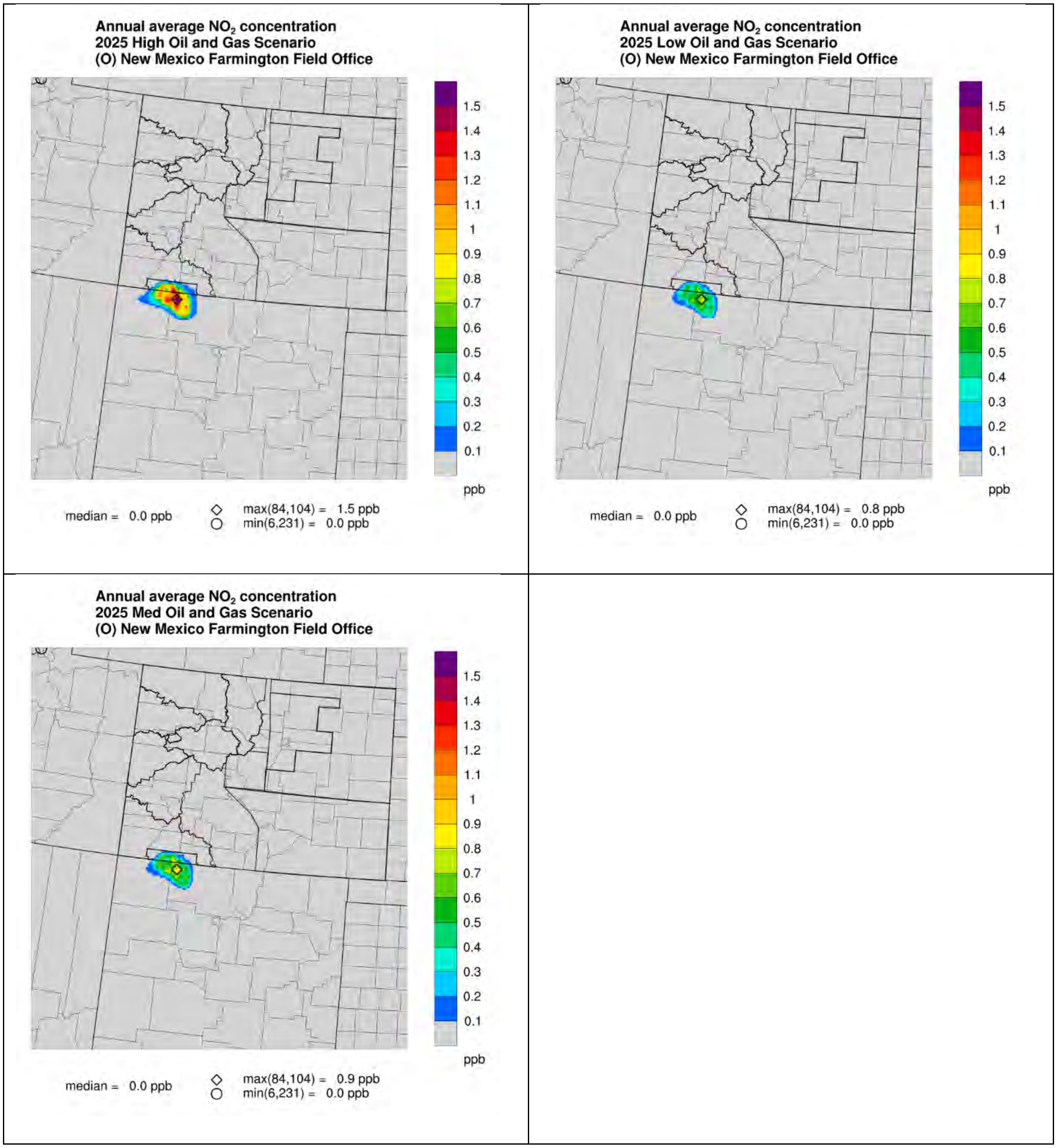

Figure 3-31. Contributions from New Mexico FFO to annual average NO_2 concentrations in the 2025 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

4.0 PSD POLLUTANT CONCENTRATION IMPACTS AT CLASS I AND SENSITIVE CLASS II AREAS

In this section we present the contributions of emissions to pollutant concentrations at 27 Class I and 58 sensitive Class II areas for the 2025 High, Low and Medium Development Scenarios, respectively. Results are presented for each PSD pollutant and averaging time given in Table 4-1.

The PSD incremental concentrations are reported for informational purposes only and the analyses presented in this section are not a comprehensive PSD increment consumption assessment; that assessment must be performed by the appropriate state or federal agency. Class I and Sensitive Class II Areas for Analysis

The CARMMS AQ/AQRV impacts due to oil and gas development on Federal lands within the Colorado BLM Planning Areas were assessed for the Class I areas and sensitive Class II areas identified in CARMMS 1.0/1.5 (Ramboll Environ and Kleinfelder, 2016a, Parker and Morris, 2014) within the CARMMS 2.0 12/4 km modeling domain. GIS analysis was performed to determine the grid cell definition of the identified Class I/II areas within the CARMMS 2.0 12/4 km modeling domain. Sensitive lakes in the region were also identified.

Table 4-1. Applicable National and State Ambient Air Quality Standards and PSD concentration increments (bold indicates units in which standard was defined, conversion to ppm/ppb following CDPHE modeling guidance).

Pollutant/Averaging Time	NAAQS	CAAQS[13]	NMAAQS[14]	PSD Class I Increment[1]	PSD Class II Increment[1]
CO					
1-hour[2]	**35 ppm** 40,000 µg/m^3	--	**13.1 ppm** 1,100 µg/m^3	--	--
8-hour[2]	**9 ppm** 10,000 µg/m^3	--	**8.7 ppm** 10,000 µg/m^3	--	--
NO_2					
1-hour[3]	**100 ppb** 188 µg/m^3	--	--	--	--
24-hour	--	--	**0.10 ppm** 1,953 µg/m^3	--	--
Annual[4]	**53 ppb** 100 µg/m^3	--	**0.05 ppm** 98 µg/m^3	2.5 µg/m^3	25 µg/m^3
O_3					
8-hour[5]	**0.070 ppm** 137 µg/m^3	--	--	--	--
PM_{10}					
24-hour[6]	**150 µg/m^3**	--	--	8 µg/m^3	30 µg/m^3
Annual[7]	--	--	--	4 µg/m^3	17 µg/m^3
$PM_{2.5}$					
24-hour[8]	**35 µg/m^3**	--	--	2 µg/m^3	9 µg/m^3
Annual[9]	**12 µg/m^3**	--	--	1 µg/m^3	4 µg/m^3
SO_2					
1-hour[10]	**75 ppb** 196 µg/m^3	--	--		
3-hour[11]	**0.5 ppm** 1,300 µg/m^3	**700 µg/m^3**	--	25 µg/m^3	512 µg/m^3
24-hour[12]	--	--	**0.10 ppm** 262 µg/m^3	5 µg/m^3	91 µg/m^3
Annual[4]	--	--	**0.02 ppm** 52 µg/m^3	2 µg/m^3	20 µg/m^3

1. The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
2. No more than one exceedance per calendar year; for NMAAQS - No more than one exceedance per consecutive 12 months
3. 98th percentile, averaged over 3 year; for NMAAQS - not to be exceeded more than once over any 12 consecutive months
4. Annual mean not to be exceeded; for NMAAQS - arithmetic average over any four consecutive quarters not to be exceeded
5. Fourth-highest daily maximum 8-hour ozone concentrations in a year, averaged over 3 years
6. Not to be exceeded more than once per calendar year on average over 3 years.
7. 3-year average of the arithmetic means over a calendar year
8. 98th percentile, averaged over 3 years
9. Annual mean, averaged over 3 years, NAAQS promulgated December 14, 2012
10. 99th percentile of daily maximum 1-hour concentrations in a year, averaged over 3 years
11. No more than one exceedance per calendar year (secondary NAAQS) and no more than one exceedance in 12 consecutive months (CAAQS)
12. For areas in New Mexico not within 3.5 miles of the Chino Mines Company
13. http://www.colorado.gov/cs/Satellite/CDPHE-Main/CBON/1251601911433

14. http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.htm

4.1 Class I and Sensitive Class II Areas

The Class I areas where air quality and AQRV impacts were calculated within the 12/4 km CARMMS 2.0 modeling domain are displayed in Figure 4-1 and listed in Table 4-2. The sensitive Class II areas used in the CARMMS post-processing are displayed in Figure 4-2, Figure 4-3, and Figure 4-4 and listed in Table 4-3. Note that several of the Class I areas are portions of a sensitive Class II area. In total, the CARMMS modeling results were post-processed using 26 and 58 Class I and sensitive Class II areas, respectively. Details on how the sensitive Class II areas were defined are provided in Parker and Morris (2014). Note that the Colorado side of Dinosaur National Monument is considered PSD Class I for just SO_2. Sensitive lakes in the region where ANC calculations are made are listed in Table 7-1.

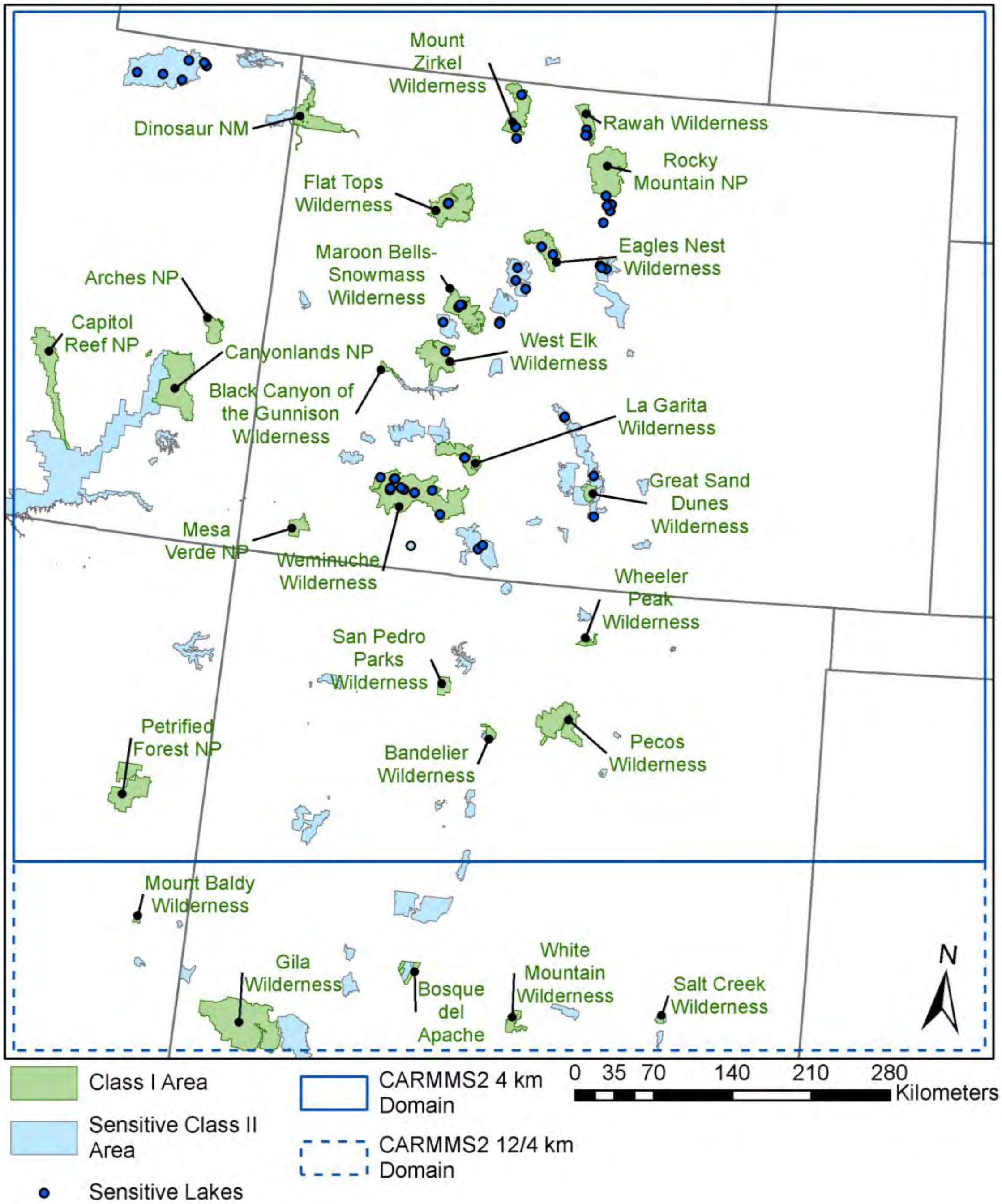

Figure 4-1. Locations of Class I (light green) and sensitive Class II (light blue) areas where air quality and AQRV impacts were assessed as well as sensitive lakes (blue dots with black outlines) with ANC calculations. Class I areas are labelled, while sensitive Class II areas and sensitive lakes are not.

Table 4-2. List of Class I Areas for Impact Analysis.

Class I	State	Owner
Arches NP	UT	NPS
Bandelier Wilderness	NM	NPS
Black Canyon of the Gunnison Wilderness	CO	NPS
Bosque del Apache	NM	FWS
Canyonlands NP	UT	NPS
Capitol Reef NP	UT	NPS
Dinosaur NM[1]	CO	NPS
Eagles Nest Wilderness	CO	USFS
Flat Tops Wilderness	CO	USFS
Gila Wilderness	NM	USFS
Great Sand Dunes Wilderness	CO	NPS
La Garita Wilderness	CO	USFS
Maroon Bells-Snowmass Wilderness	CO	USFS
Mesa Verde NP	CO	NPS
Mount Baldy Wilderness	AZ	USFS
Mount Zirkel Wilderness	CO	USFS
Pecos Wilderness	NM	USFS
Petrified Forest NP	AZ	NPS
Rawah Wilderness	CO	USFS
Rocky Mountain NP	CO	NPS
Salt Creek Wilderness	NM	FWS
San Pedro Parks Wilderness	NM	USFS
Weminuche Wilderness	CO	USFS
West Elk Wilderness	CO	USFS
Wheeler Peak Wilderness	NM	USFS
White Mountain Wilderness	NM	USFS

1. The Colorado side of Dinosaur NM is PSD Class I for SO_2

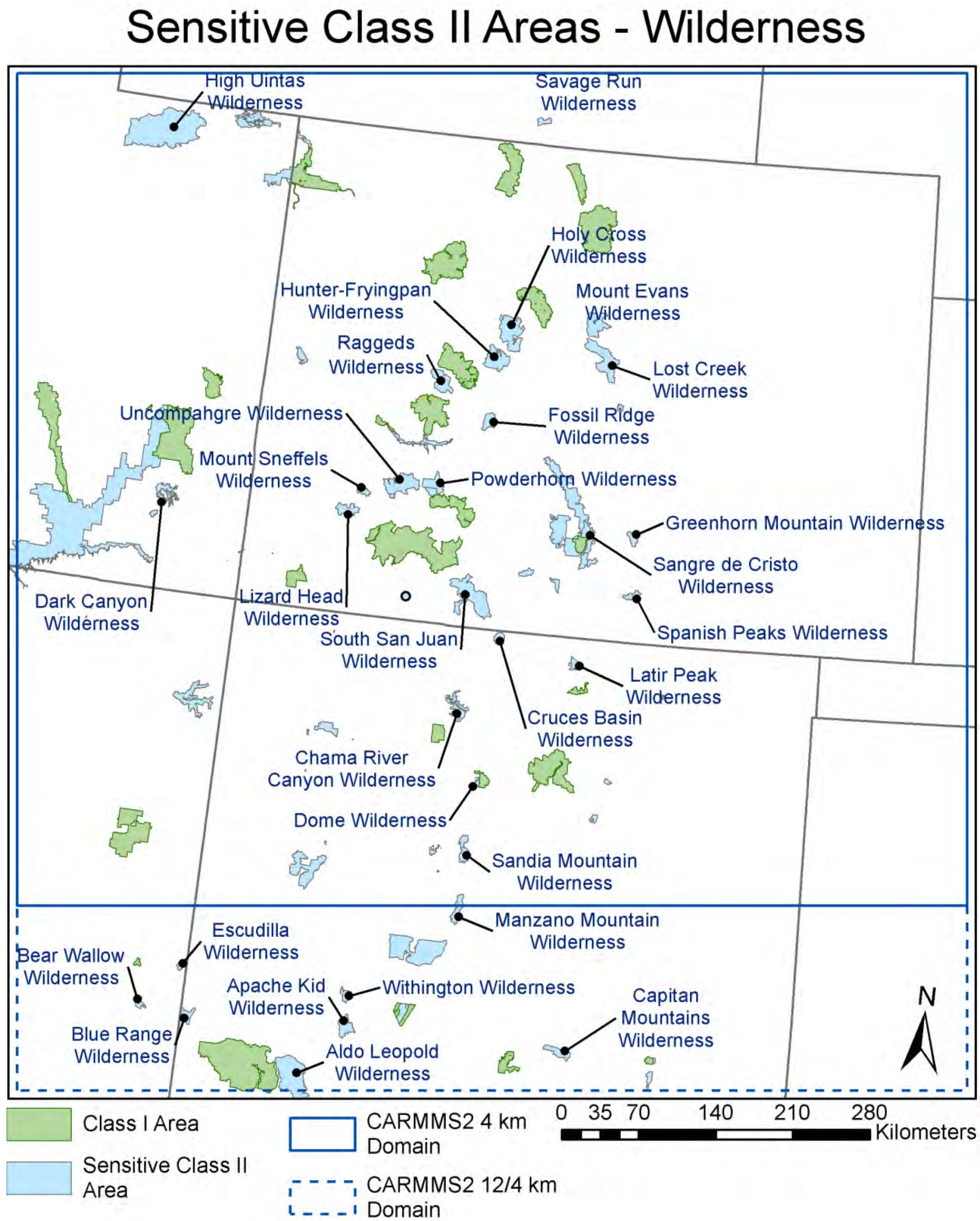

Figure 4-2. Sensitive Class II wilderness areas for the CARMMS analysis labeled. Class I areas and non-wilderness sensitive Class II areas unlabelled.

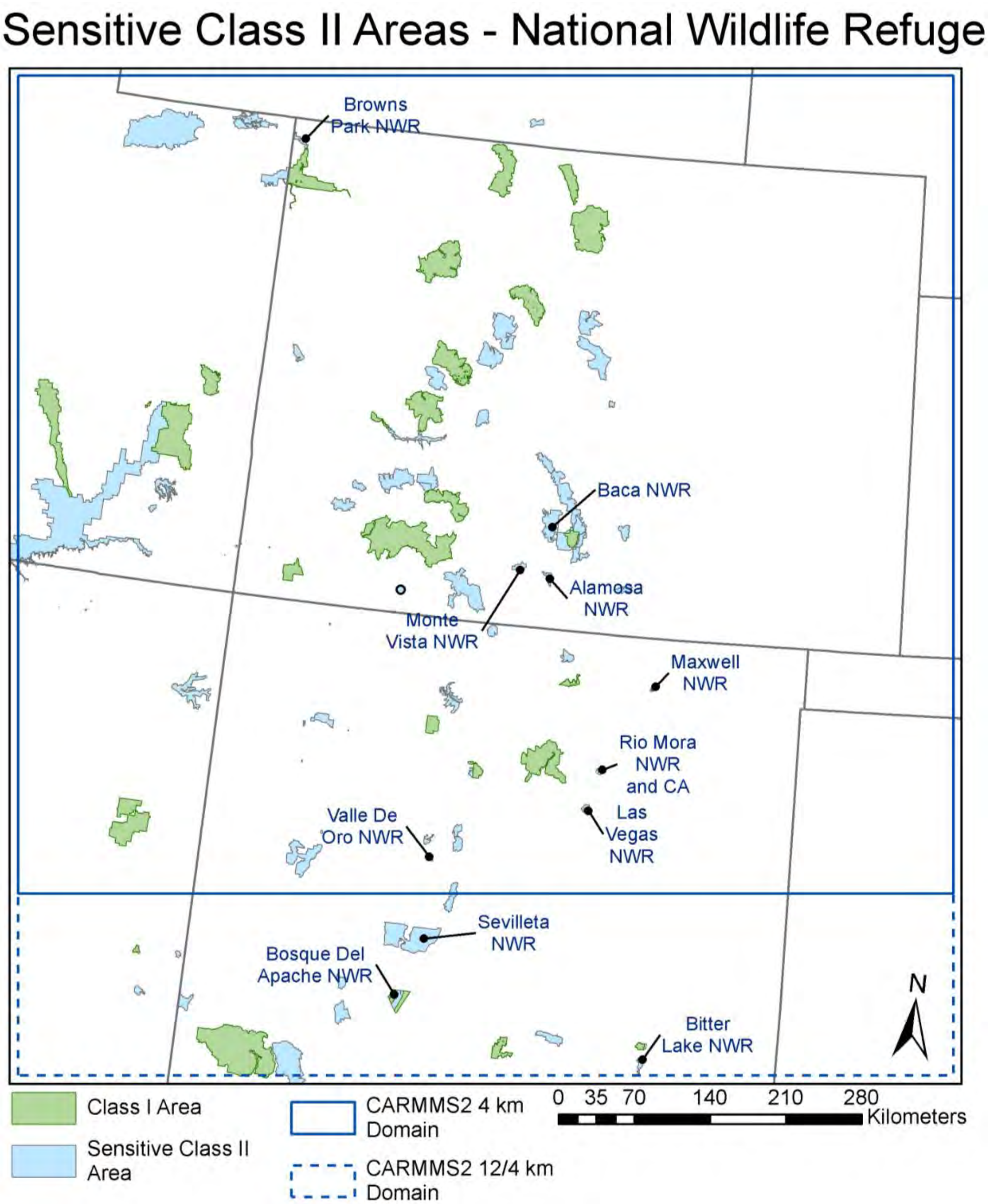

Figure 4-3. National Wildlife Refuge sensitive Class II areas for the CARMMS analysis labeled. Class I area and non-National-Wildlife-Refuge Class II areas displayed but not labeled.

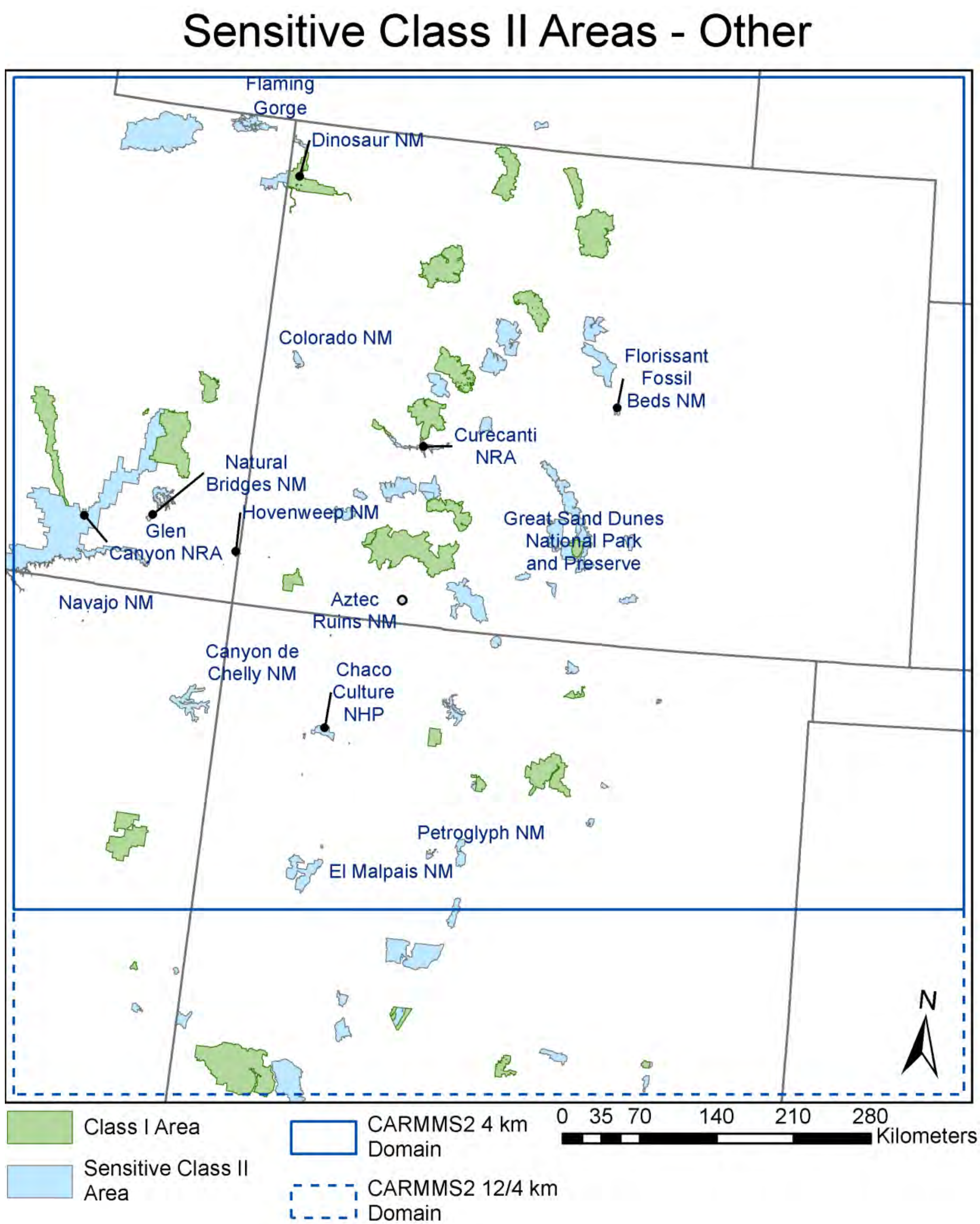

Figure 4-4. **Other sensitive Class II areas for the CARMMS analysis labeled. Class I areas and Class II areas shown in Figure 4-3a and Figure 4-3b are also shown but not labelled.**

Table 4-3. Sensitive Class II areas where air quality and AQRV impacts were assessed.

Class II	State	Owner
Alamosa National Wildlife Refuge	CO	FWS
Aldo Leopold Wilderness	NM	USFS
Apache Kid Wilderness	NM	USFS
Aztec Ruins NM	NM	NPS
Baca National Wildlife Refuge	CO	FWS
Bear Wallow Wilderness	AZ	USFS
Bitter Lake National Wildlife Refuge	NM	FWS
Blue Range Wilderness	NM	USFS
Bosque Del Apache National Wildlife Refuge	NM	FWS
Browns Park National Wildlife Refuge	CO	FWS
Canyon de Chelly NM	AZ	NPS
Capitan Mountains Wilderness	NM	USFS
Chaco Culture NHP	NM	NPS
Chama River Canyon Wilderness	NM	USFS
Chimney Rock NM	CO	USFS
Colorado NM	CO	NPS
Cruces Basin Wilderness	NM	USFS
Curecanti NRA	CO	NPS
Dark Canyon Wilderness	UT	USFS
Dinosaur NM	CO	NPS
Dome Wilderness	NM	USFS
El Malpais NM	NM	NPS
Escudilla Wilderness	AZ	USFS
Flaming Gorge	UT	USFS
Florissant Fossil Beds NM	CO	NPS
Fossil Ridge Wilderness	CO	USFS
Glen Canyon NRA	UT	NPS
Great Sand Dunes National Park	CO	NPS
Great Sand Dunes National Preserve	CO	NPS
Greenhorn Mountain Wilderness	CO	USFS
High Uintas Wilderness	UT	USFS
Holy Cross Wilderness	CO	USFS
Hovenweep NM	CO	NPS
Hunter-Fryingpan Wilderness	CO	USFS
Las Vegas National Wildlife Refuge	NM	FWS
Latir Peak Wilderness	NM	USFS
Lizard Head Wilderness	CO	USFS
Lost Creek Wilderness	CO	USFS
Manzano Mountain Wilderness	NM	USFS
Maxwell National Wildlife Refuge	NM	FWS
Monte Vista National Wildlife Refuge	CO	FWS
Mount Evans Wilderness	CO	USFS
Mount Sneffels Wilderness	CO	USFS
Natural Bridges NM	UT	NPS
Navajo NM	AZ	NPS
Petroglyph NM	NM	NPS
Powderhorn Wilderness	CO	USFS
Raggeds Wilderness	CO	USFS

Class II	State	Owner
Rio Mora National Wildlife Refuge and Conservation Area	NM	FWS
Sandia Mountain Wilderness	NM	USFS
Sangre de Cristo Wilderness	CO	USFS
Savage Run Wilderness	WY	USFS
Sevilleta National Wildlife Refuge	NM	FWS
South San Juan Wilderness	CO	USFS
Spanish Peaks Wilderness	CO	USFS
Uncompahgre Wilderness	CO	USFS
Valle De Oro National Wildlife Refuge	NM	FWS
Withington Wilderness	NM	USFS

4.2 PSD Pollutant Concentration Impacts at Class I and Sensitive Class II Areas

In this section we report the contributions of PSD pollutant concentrations across all PSD Class I and sensitive Class II areas for due to emissions from the FFO for each development scenario. We also present contributions for natural sources and 2011 Base Case Total Emissions and 2025 total Emissions for each development scenario.

The PSD incremental concentrations are reported for informational purposes only and the analyses presented in this section are not a comprehensive PSD increment consumption assessment; that assessment must be performed by the appropriate state or federal agency.

4.2.1 Maximum PSD Concentration Impacts at any Class I or II Area

EPA has defined PSD Concentrations Increments for Class I and II areas for 8 different pollutant concentration/averaging time combinations (see Table 4-1). In this section we present the "Maximum" PSD concentration impacts at Class I and sensitive Class II areas due to the FFO and other cumulative source groups. Note that the thresholds are project-level thresholds and the comparisons with total emissions are for informational purposes only. The modeled impacts are based on the CAMx Particulate Source Apportionment Technology (PSAT) source apportionment contributions. For short-term averaging times (i.e., not annual), the highest second high concentration at each Class I/II area is selected for comparison with the PSD increment.

4.2.1.1 NO_2 PSD Concentrations

The maximum contribution to annual NO_2 concentrations at any Class I or sensitive Class II area due to emissions from natural emissions, FFO emissions, 2025 total emissions and 2011 base case emissions are presented in Table 4-4. The FFO and 2025 total contributions vary by development scenario. The FFO maximum contribution to Class I area FFO PSD increments are 1.3 %, 0.7 % and 0.7 % for the high, low and medium scenarios, respectively, and all occur at Mesa Verde.

Table 4-4. Maximum annual NO_2 concentration at any Class I or sensitive Class II area due to the cumulative sources and the FFO for High, Low, and Medium Development scenarios.

Choose	NO2, Annual	µg/m3						
Across grid cells	**Maximum**							
Group Name	**PSD Class I Increment**	**Max @ any Class I area**	**Percent of PSD Class I Increm ent**	**Class I Area where Max occurred**	**PSD Class II Incre ment**	**Max @ any Class II area**	**Percent of PSD Class II Increment**	**Class II Area where Max occurred**
Natural emissions	2.5	5.562	222.5%	Bandelier	25	4.281	17.1%	Bear_Wallow
New Mexico Farmington Field Office: High	2.5	0.033	1.3%	Mesa_Verde	25	1.674	6.7%	Aztec_Ruins
New Mexico Farmington Field Office: Low	2.5	0.016	0.7%	Mesa_Verde	25	0.828	3.3%	Aztec_Ruins
New Mexico Farmington Field Office: Medium	2.5	0.019	0.7%	Mesa_Verde	25	0.947	3.8%	Aztec_Ruins
2025 Total: High	2.5	6.097	243.9%	Bandelier	25	9.901	39.6%	Aztec_Ruins
2025 Total: Low	2.5	6.088	243.5%	Bandelier	25	8.330	33.3%	Aztec_Ruins
2025 Total: Medium	2.5	6.093	243.7%	Bandelier	25	8.783	35.1%	Aztec_Ruins
2011 Total	2.5	7.986	319.5%	Petrified_Forest	25	23.05 9	92.2%	Aztec_Ruins

4.2.1.2 SO_2 PSD Concentrations

Table 4-5, Table 4-6, and Table 4-7 present the comparison of the maximum annual, 24-hour and 3-hour SO_2 contributions due to natural emissions, FFO emissions and 2025 total and 2011 base case emissions respectively, with the PSD SO_2 increments at Class I/II areas. Note that the Colorado portion of the Dinosaur National Monument is Class I for SO_2 only, so it may be included in the Class I area grouping in these tables. Note that PSD Increments are not applicable for natural or 2025 total not 2011 base case emissions. The FFO does not exceed the annual, 24-hour and 3-hour PSD Class I Increment at any Class I/II area in any of the scenarios. The FFO contributions are very small, less than 0.1% of the PSD Increments.

Table 4-5. Maximum annual SO_2 concentration at any Class I or sensitive Class II area due to cumulative sources and the FFO for High, Low, and Medium Development scenarios.

Choose	SO2, Annual	µg/m3						
Across grid cells	Maximum							
Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
Natural emissions	2	2.726	136.3%	Bandelier	20	2.002	10.0%	Bear_Wallow
Farmington Field Office : High	2	0.000	0.0%	Mesa_Verde	20	0.003	0.0%	Aztec_Ruins
Farmington Field Office: Low	2	0.000	0.0%	Mesa_Verde	20	0.001	0.0%	Aztec_Ruins
Farmington Field Office: Medium	2	0.000	0.0%	Mesa_Verde	20	0.003	0.0%	Aztec_Ruins
2025 Total: High	2	2.888	144.4%	Bandelier	20	2.270	11.3%	Bear_Wallow
2025 Total: Low	2	2.887	144.4%	Bandelier	20	2.270	11.3%	Bear_Wallow
2025 Total: Medium	2	2.888	144.4%	Bandelier	20	2.270	11.3%	Bear_Wallow
2011 Total	2	2.986	149.3%	Bandelier	20	2.502	12.5%	Bear_Wallow

Table 4-6. Maximum 24-hour SO_2 concentration at any Class I or sensitive Class II area due to cumulative sources and the FFO for High, Low, and Medium Development scenarios.

Choose	SO2, 24-hour	µg/m3							
Across grid cells	Maximum								
Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment		Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
Natural emissions	5	210.991	4219.8%		Bandelier	91	108.145	118.8%	Bear_Wallow
Farmington Field Office : High	5	0.001	0.0%		Mesa_Verde	91	0.008	0.0%	Aztec_Ruins
Farmington Field Office: Low	5	0.000	0.0%		Mesa_Verde	91	0.004	0.0%	Aztec_Ruins
Farmington Field Office: Medium	5	0.001	0.0%		Mesa_Verde	91	0.008	0.0%	Aztec_Ruins
2025 Total: High	5	211.072	4221.4%		Bandelier	91	108.266	119.0%	Bear_Wallow
2025 Total: Low	5	211.072	4221.4%		Bandelier	91	108.266	119.0%	Bear_Wallow
2025 Total: Medium	5	211.072	4221.4%		Bandelier	91	108.266	119.0%	Bear_Wallow
2011 Total	5	211.109	4222.2%		Bandelier	91	108.726	119.5%	Bear_Wallow

Table 4-7. Maximum 3-hour SO_2 concentration at any Class I or sensitive Class II area due to cumulative sources and the FFO for High, Low, and Medium Development scenarios.

Choose	SO2, 3-hour	µg/m3						
Across grid cells	Maximum							
Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
Natural emissions	25	587.662	2350.6%	Bandelier	512	337.323	65.9%	Dome
Farmington Field Office : High	25	0.002	0.0%	Mesa_Verde	512	0.013	0.0%	Aztec_Ruins
Farmington Field Office: Low	25	0.001	0.0%	Mesa_Verde	512	0.007	0.0%	Aztec_Ruins
Farmington Field Office: Medium	25	0.002	0.0%	Mesa_Verde	512	0.012	0.0%	Aztec_Ruins
2025 Total: High	25	587.878	2351.5%	Bandelier	512	337.436	65.9%	Dome
2025 Total: Low	25	587.878	2351.5%	Bandelier	512	337.436	65.9%	Dome
2025 Total: Medium	25	587.878	2351.5%	Bandelier	512	337.436	65.9%	Dome
2011 Total	25	587.900	2351.6%	Bandelier	512	338.092	66.0%	Dome

4.2.1.3 PM$_{2.5}$ PSD Concentrations

Table 4-8 and Table 4-9 display the maximum annual and 24-hour PM$_{2.5}$ concentrations due the FFO and natural sources and 2025 total emissions and 2011 base case emissions at any Class I and II area and presents a comparison with the PSD PM$_{2.5}$ Increments for the 2025 High, Low and Medium Development Scenarios. PM$_{2.5}$ concentrations due to emissions from the FFO do not come close to exceeding any of the PSD PM$_{2.5}$ Increments.

Extremely high maximum annual and 24-hour PM$_{2.5}$ contributions are seen due to natural wildfire emissions that occurred in 2011, which are also reflected in the total 2025 and 2011 base case contributions for which the PSD increments are not applicable.

Table 4-8. Maximum Annual PM$_{2.5}$ concentration at any Class I or sensitive Class II area due to cumulative sources and the FFO for High, Low, and Medium Development scenarios

Choose	PM2.5, Annual	µg/m 3						
Across grid cells	Maximum							
Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
Natural emissions	1	7.833	783.3%	Bandelier	4	6.155	153.9%	Bear_Wallow
Farmington Field Office : High	1	0.006	0.6%	Mesa_Verde	4	0.183	4.6%	Aztec_Ruins
Farmington Field Office: Low	1	0.003	0.3%	Mesa_Verde	4	0.092	2.3%	Aztec_Ruins
Farmington Field Office: Medium	1	0.003	0.3%	Mesa_Verde	4	0.095	2.4%	Aztec_Ruins
2025 Total: High	1	9.724	972.4%	Bandelier	4	12.140	303.5%	Valle_De_Oro_NWR
2025 Total: Low	1	9.720	972.0%	Bandelier	4	12.132	303.3%	Valle_De_Oro_NWR
2025 Total: Medium	1	9.722	972.2%	Bandelier	4	12.137	303.4%	Valle_De_Oro_NWR
2011 Total	1	9.781	978.1%	Bandelier	4	11.197	279.9%	Valle_De_Oro_NWR

Table 4-9. Maximum 24-Hour $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to cumulative sources and the FFO for High, Low, and Medium Development scenarios.

Choose	PM2.5 , 24-hour	µg/m3						
Across grid cells	Maximum							
Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
Natural emissions	2	593.477	29673.8%	Bandelier	9	332.517	3694.6%	Bear_Wallow
Farmington Field Office : High	2	0.063	3.2%	Mesa_Verde	9	0.595	6.6%	Aztec_Ruins
Farmington Field Office: Low	2	0.032	1.6%	Mesa_Verde	9	0.306	3.4%	Aztec_Ruins
Farmington Field Office: Medium	2	0.033	1.6%	Mesa_Verde	9	0.316	3.5%	Aztec_Ruins
2025 Total: High	2	608.768	30438.4%	Bandelier	9	342.197	3802.2%	Bear_Wallow
2025 Total: Low	2	608.767	30438.3%	Bandelier	9	342.197	3802.2%	Bear_Wallow
2025 Total: Medium	2	608.767	30438.4%	Bandelier	9	342.197	3802.2%	Bear_Wallow
2011 Total	2	609.031	30451.6%	Bandelier	9	342.838	3809.3%	Bear_Wallow

4.2.1.4 PM_{10} PSD Concentrations

The results of the comparisons against the PM_{10} PSD increments are similar to $PM_{2.5}$ with Natural Emissions (that are also included in the total 2025 and 2011), exceeding the annual and 24-hour PM_{10} PSD increment as shown in Table 4-10 and Table 4-11. The FFO high development scenario has annual and 24-hour PM_{10} at any Class I area with maximum values of 0.6% and 2.3 % of the PSD PM_{10} increment both at Mesa Verde. Note that in some cases the Medium Development Scenario may have lower impacts than the Low Development Scenario for PM_{10} due to the Medium Development Scenario having high mitigation that resulted in lower emissions of PM10 than the Low Development Scenario.

Table 4-10. Maximum Annual PM_{10} concentration at any Class I or sensitive Class II area due to cumulative sources and the FFO for High, Low, and Medium Development scenarios.

Choose	PM10, Annual	µg/m3						
Across grid cells	Maximum							
Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
Natural emissions	4	9.282	232.0%	Bandelier	17	9.167	53.9%	Sevilleta_NWR
Farmington Field Office : High	4	0.022	0.6%	Mesa_Verde	17	0.828	4.9%	Aztec_Ruins
Farmington Field Office: Low	4	0.011	0.3%	Mesa_Verde	17	0.416	2.4%	Aztec_Ruins
Farmington Field Office: Medium	4	0.009	0.2%	Mesa_Verde	17	0.324	1.9%	Aztec_Ruins
2025 Total: High	4	16.212	405.3%	Bandelier	17	70.901	417.1%	Valle_De_Oro_NWR
2025 Total: Low	4	16.201	405.0%	Bandelier	17	70.890	417.0%	Valle_De_Oro_NWR
2025 Total: Medium	4	16.205	405.1%	Bandelier	17	70.897	417.0%	Valle_De_Oro_NWR
2011 Total	4	13.893	347.3%	Bandelier	17	58.983	347.0%	Valle_De_Oro_NWR

Table 4-11. Maximum 24-Hour PM_{10} concentration at any Class I or sensitive Class II area due to cumulative sources and the FFO for High, Low, and Medium Development scenarios.

Choose	PM10, 24-hour	µg/m3						
Across grid cells	Maximum							
Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
Natural emissions	8	674.493	8431.2%	Bandelier	30	372.753	1242.5%	Bear_Wallow
Farmington Field Office : High	8	0.186	2.3%	Mesa_Verde	30	2.129	7.1%	Aztec_Ruins
Farmington Field Office: Low	8	0.094	1.2%	Mesa_Verde	30	1.076	3.6%	Aztec_Ruins
Farmington Field Office: Medium	8	0.076	0.9%	Mesa_Verde	30	0.862	2.9%	Aztec_Ruins
2025 Total: High	8	692.086	8651.1%	Bandelier	30	383.645	1278.8%	Bear_Wallow
2025 Total: Low	8	692.079	8651.0%	Bandelier	30	383.645	1278.8%	Bear_Wallow
2025 Total: Medium	8	692.079	8651.0%	Bandelier	30	383.645	1278.8%	Bear_Wallow
2011 Total	8	692.117	8651.5%	Bandelier	30	384.256	1280.9%	Bear_Wallow

4.2.2 PSD Concentration across All Class I and Sensitive Class II Areas

In this section we present the contributions of FFO emissions to PSD increments across all PSD Class I and sensitive Class II areas for each FFO development scenario.

Table 4-12 and Table 4-13 present the High Development scenario results for the Class I and sensitive Class II areas, respectively, and show that the concentrations are far below the PSD thresholds at all Class I/II areas. The maximum concentrations occur at Mesa Verde, and Aztec Ruins (as reported in previous section) and the concentrations at the other Class I/II areas are much lower. Generally, the second most impacted Class I area is Weminuche.

Table 4-14, Table 4-15, Table 4-16, and Table 4-17 present the analogous results for the Low Development Scenario and Medium Development Scenario.

Table 4-12. Contributions of FFO emissions to PSD pollutant concentrations at Class I areas for the 2025 High Development Scenario.

		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	**Annual[3]**	**24-hour[2]**	**Annual[3]**	**24-hour[4]**	**Annual[3]**	**3-hour[2]**	**24-hour[2]**	**Annual[3]**
Class I	**State**	**Owner**	**PSD Class I Increment[1]**							
			2.5	**8**	**4**	**2**	**1**	**25**	**5**	**2**
Arches NP	UT	NPS	0.001	0.022	0.001	0.009	0.000	0.000	0.000	0.000
Bandelier Wilderness	NM	NPS	0.010	0.085	0.009	0.027	0.002	0.001	0.000	0.000
Black Canyon of the Gunnison Wilderness	CO	NPS	0.001	0.013	0.002	0.005	0.001	0.000	0.000	0.000
Bosque del Apache	NM	FWS	0.000	0.023	0.001	0.012	0.000	0.000	0.000	0.000
Canyonlands NP	UT	NPS	0.003	0.045	0.003	0.014	0.001	0.000	0.000	0.000
Capitol Reef NP	UT	NPS	0.001	0.034	0.001	0.010	0.000	0.000	0.000	0.000
Dinosaur NM	CO	NPS	0.000	0.012	0.000	0.005	0.000	0.000	0.000	0.000
Eagles Nest Wilderness	CO	USFS	0.001	0.006	0.001	0.002	0.000	0.000	0.000	0.000
Flat Tops Wilderness	CO	USFS	0.000	0.006	0.001	0.002	0.000	0.000	0.000	0.000
Gila Wilderness	NM	USFS	0.000	0.008	0.000	0.003	0.000	0.000	0.000	0.000
Great Sand Dunes Wilderness-NPS	CO	NPS	0.004	0.027	0.004	0.010	0.001	0.000	0.000	0.000
La Garita Wilderness	CO	USFS	0.005	0.027	0.004	0.009	0.001	0.000	0.000	0.000
Maroon Bells-Snowmass Wilderness	CO	USFS	0.001	0.010	0.001	0.004	0.000	0.000	0.000	0.000
Mesa Verde NP	**CO**	**NPS**	**0.033**	**0.186**	**0.022**	**0.063**	**0.006**	**0.002**	**0.001**	**0.000**
Mount Baldy Wilderness	AZ	USFS	0.000	0.006	0.000	0.002	0.000	0.000	0.000	0.000
Mount Zirkel Wilderness	CO	USFS	0.000	0.006	0.000	0.002	0.000	0.000	0.000	0.000
Pecos Wilderness	NM	USFS	0.008	0.087	0.008	0.027	0.002	0.001	0.000	0.000
Petrified Forest NP	AZ	NPS	0.000	0.016	0.000	0.005	0.000	0.000	0.000	0.000
Rawah Wilderness	CO	USFS	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000
Rocky Mountain NP	CO	NPS	0.000	0.005	0.001	0.003	0.000	0.000	0.000	0.000
Salt Creek Wilderness	NM	FWS	0.001	0.011	0.001	0.003	0.000	0.000	0.000	0.000
San Pedro Parks Wilderness	NM	USFS	0.014	0.086	0.010	0.022	0.003	0.001	0.000	0.000
Weminuche Wilderness	CO	USFS	0.031	0.121	0.021	0.042	0.006	0.002	0.001	0.000
West Elk Wilderness	CO	USFS	0.001	0.012	0.001	0.005	0.000	0.000	0.000	0.000
Wheeler Peak Wilderness	NM	USFS	0.006	0.038	0.005	0.011	0.001	0.000	0.000	0.000
White Mountain Wilderness	NM	USFS	0.000	0.011	0.001	0.003	0.000	0.000	0.000	0.000

Table 4-13. Contributions of FFO emissions to PSD pollutant concentrations at sensitive Class II areas for the 2025 High Development Scenario.

Class II	State	Owner	PSD Class II Increment[1]							
			25	30	17	9	4	512	91	20
Alamosa National Wildlife Refuge	CO	FWS	0.007	0.056	0.007	0.030	0.003	0.000	0.000	0.000
Aldo Leopold Wilderness	NM	USFS	0.000	0.007	0.000	0.003	0.000	0.000	0.000	0.000
Apache Kid Wilderness	NM	USFS	0.000	0.009	0.000	0.004	0.000	0.000	0.000	0.000
Aztec Ruins NM	**NM**	**NPS**	**1.674**	**2.129**	**0.828**	**0.595**	**0.183**	**0.013**	**0.008**	**0.003**
Baca National Wildlife Refuge	CO	FWS	0.005	0.038	0.005	0.025	0.002	0.000	0.000	0.000
Bear Wallow Wilderness	AZ	USFS	0.000	0.007	0.000	0.002	0.000	0.000	0.000	0.000
Bitter Lake National Wildlife Refuge	NM	FWS	0.001	0.011	0.001	0.003	0.000	0.000	0.000	0.000
Blue Range Wilderness	NM	USFS	0.000	0.007	0.000	0.003	0.000	0.000	0.000	0.000
Bosque Del Apache National Wildlife Refuge	NM	FWS	0.000	0.023	0.001	0.012	0.000	0.000	0.000	0.000
Browns Park National Wildlife Refuge	CO	FWS	0.000	0.009	0.000	0.003	0.000	0.000	0.000	0.000
Canyon de Chelly NM	AZ	NPS	0.001	0.061	0.001	0.044	0.001	0.001	0.000	0.000
Capitan Mountains Wilderness	NM	USFS	0.000	0.010	0.001	0.003	0.000	0.000	0.000	0.000
Chaco Culture NHP	NM	NPS	0.006	0.066	0.004	0.023	0.001	0.001	0.000	0.000
Chama River Canyon Wilderness	NM	USFS	0.057	0.219	0.033	0.063	0.009	0.002	0.001	0.000
Chimney Rock NM	CO	USFS	0.161	0.355	0.086	0.108	0.023	0.003	0.002	0.000
Colorado NM	CO	NPS	0.001	0.019	0.001	0.011	0.000	0.000	0.000	0.000
Cruces Basin Wilderness	NM	USFS	0.024	0.089	0.017	0.024	0.005	0.001	0.000	0.000
Curecanti NRA	CO	NPS	0.002	0.012	0.001	0.005	0.000	0.000	0.000	0.000
Dark Canyon Wilderness	UT	USFS	0.004	0.063	0.003	0.019	0.001	0.001	0.000	0.000
Dinosaur NM	CO	NPS	0.000	0.014	0.000	0.005	0.000	0.000	0.000	0.000
Dome Wilderness	NM	USFS	0.007	0.049	0.006	0.020	0.002	0.000	0.000	0.000
El Malpais NM	NM	NPS	0.001	0.028	0.001	0.009	0.000	0.000	0.000	0.000
Escudilla Wilderness	AZ	USFS	0.000	0.008	0.000	0.002	0.000	0.000	0.000	0.000
Flaming Gorge	UT	USFS	0.000	0.006	0.000	0.003	0.000	0.000	0.000	0.000
Florissant Fossil Beds NM	CO	NPS	0.001	0.008	0.001	0.004	0.000	0.000	0.000	0.000
Fossil Ridge Wilderness	CO	USFS	0.001	0.011	0.001	0.005	0.000	0.000	0.000	0.000
Glen Canyon NRA	UT	NPS	0.009	0.134	0.008	0.048	0.002	0.001	0.000	0.000
Great Sand Dunes National Park	CO	NPS	0.005	0.035	0.004	0.012	0.001	0.000	0.000	0.000
Great Sand Dunes National Preserve	CO	NPS	0.004	0.025	0.004	0.008	0.001	0.000	0.000	0.000
Greenhorn Mountain Wilderness	CO	USFS	0.003	0.018	0.002	0.005	0.001	0.000	0.000	0.000
High Uintas Wilderness	UT	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Holy Cross Wilderness	CO	USFS	0.001	0.007	0.001	0.003	0.000	0.000	0.000	0.000
Hovenweep NM	CO	NPS	0.013	0.111	0.011	0.038	0.003	0.001	0.000	0.000
Hunter-Fryingpan Wilderness	CO	USFS	0.001	0.008	0.001	0.004	0.000	0.000	0.000	0.000
Las Vegas National Wildlife Refuge	NM	FWS	0.003	0.025	0.003	0.011	0.001	0.000	0.000	0.000
Latir Peak Wilderness	NM	USFS	0.006	0.039	0.005	0.009	0.001	0.000	0.000	0.000

Class II	State	Owner	PSD Class II Increment[1]							
			25	30	17	9	4	512	91	20
Lizard Head Wilderness	CO	USFS	0.005	0.026	0.004	0.008	0.001	0.000	0.000	0.000
Lost Creek Wilderness	CO	USFS	0.001	0.007	0.001	0.003	0.000	0.000	0.000	0.000
Manzano Mountain Wilderness	NM	USFS	0.004	0.060	0.005	0.018	0.001	0.001	0.000	0.000
Maxwell National Wildlife Refuge	NM	FWS	0.002	0.015	0.002	0.005	0.001	0.000	0.000	0.000
Monte Vista National Wildlife Refuge	CO	FWS	0.011	0.052	0.008	0.039	0.003	0.000	0.000	0.000
Mount Evans Wilderness	CO	USFS	0.001	0.006	0.001	0.003	0.000	0.000	0.000	0.000
Mount Sneffels Wilderness	CO	USFS	0.004	0.021	0.003	0.006	0.001	0.000	0.000	0.000
Natural Bridges NM	UT	NPS	0.005	0.079	0.004	0.023	0.001	0.001	0.000	0.000
Navajo NM	AZ	NPS	0.001	0.059	0.001	0.015	0.000	0.000	0.000	0.000
Petroglyph NM	NM	NPS	0.004	0.054	0.004	0.026	0.001	0.001	0.000	0.000
Powderhorn Wilderness	CO	USFS	0.003	0.023	0.003	0.006	0.001	0.000	0.000	0.000
Raggeds Wilderness	CO	USFS	0.001	0.010	0.001	0.004	0.000	0.000	0.000	0.000
Rio Mora National Wildlife Refuge and Conservation Area	NM	FWS	0.003	0.022	0.003	0.008	0.001	0.000	0.000	0.000
Sandia Mountain Wilderness	NM	USFS	0.003	0.036	0.004	0.019	0.001	0.000	0.000	0.000
Sangre de Cristo Wilderness	CO	USFS	0.005	0.028	0.004	0.009	0.001	0.000	0.000	0.000
Savage Run Wilderness	WY	USFS	0.000	0.005	0.000	0.002	0.000	0.000	0.000	0.000
Sevilleta National Wildlife Refuge	NM	FWS	0.001	0.032	0.002	0.017	0.001	0.000	0.000	0.000
South San Juan Wilderness	CO	USFS	0.057	0.162	0.037	0.050	0.010	0.002	0.001	0.000
Spanish Peaks Wilderness	CO	USFS	0.004	0.018	0.003	0.007	0.001	0.000	0.000	0.000
Uncompahgre Wilderness	CO	USFS	0.004	0.023	0.003	0.008	0.001	0.000	0.000	0.000
Valle De Oro National Wildlife Refuge	NM	FWS	0.003	0.052	0.004	0.028	0.002	0.000	0.000	0.000
Withington Wilderness	NM	USFS	0.000	0.012	0.000	0.005	0.000	0.000	0.000	0.000

Table 4-14. Contributions of FFO emissions to PSD pollutant concentrations at Class I areas for the 2025 Low Development Scenario.

		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		PM_{25} (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.001	0.011	0.001	0.004	0.000	0.000	0.000	0.000
Bandelier Wilderness	NM	NPS	0.005	0.042	0.004	0.013	0.001	0.000	0.000	0.000
Black Canyon of the Gunnison Wilderness	CO	NPS	0.001	0.007	0.001	0.002	0.000	0.000	0.000	0.000
Bosque del Apache	NM	FWS	0.000	0.012	0.000	0.006	0.000	0.000	0.000	0.000
Canyonlands NP	UT	NPS	0.001	0.023	0.001	0.007	0.000	0.000	0.000	0.000
Capitol Reef NP	UT	NPS	0.001	0.017	0.001	0.005	0.000	0.000	0.000	0.000
Dinosaur NM	CO	NPS	0.000	0.006	0.000	0.002	0.000	0.000	0.000	0.000
Eagles Nest Wilderness	CO	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Flat Tops Wilderness	CO	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Gila Wilderness	NM	USFS	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000
Great Sand Dunes Wilderness-nps	CO	NPS	0.002	0.014	0.002	0.005	0.001	0.000	0.000	0.000
La Garita Wilderness	CO	USFS	0.002	0.014	0.002	0.005	0.001	0.000	0.000	0.000
Maroon Bells-Snowmass Wilderness	CO	USFS	0.000	0.005	0.001	0.002	0.000	0.000	0.000	0.000
Mesa Verde NP	**CO**	**NPS**	**0.016**	**0.094**	**0.011**	**0.032**	**0.003**	**0.001**	**0.000**	**0.000**
Mount Baldy Wilderness	AZ	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Mount Zirkel Wilderness	CO	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Pecos Wilderness	NM	USFS	0.004	0.044	0.004	0.014	0.001	0.000	0.000	0.000
Petrified Forest NP	AZ	NPS	0.000	0.008	0.000	0.003	0.000	0.000	0.000	0.000
Rawah Wilderness	CO	USFS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Rocky Mountain NP	CO	NPS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Salt Creek Wilderness	NM	FWS	0.000	0.005	0.000	0.002	0.000	0.000	0.000	0.000
San Pedro Parks Wilderness	NM	USFS	0.007	0.044	0.005	0.011	0.001	0.000	0.000	0.000
Weminuche Wilderness	CO	USFS	0.015	0.061	0.011	0.022	0.003	0.001	0.000	0.000
West Elk Wilderness	CO	USFS	0.001	0.006	0.001	0.002	0.000	0.000	0.000	0.000
Wheeler Peak Wilderness	NM	USFS	0.003	0.019	0.003	0.005	0.001	0.000	0.000	0.000
White Mountain Wilderness	NM	USFS	0.000	0.006	0.000	0.001	0.000	0.000	0.000	0.000

Table 4-15. Contributions of FFO emissions to PSD pollutant concentrations at sensitive Class II areas for the 2025 Low Development Scenario.

Class II	State	Owner	PSD Class II Increment[1]							
			25	30	17	9	4	512	91	20
Alamosa National Wildlife Refuge	CO	FWS	0.004	0.027	0.003	0.014	0.001	0.000	0.000	0.000
Aldo Leopold Wilderness	NM	USFS	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000
Apache Kid Wilderness	NM	USFS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000
Aztec Ruins NM	**NM**	**NPS**	**0.828**	**1.076**	**0.416**	**0.306**	**0.092**	**0.007**	**0.004**	**0.001**
Baca National Wildlife Refuge	CO	FWS	0.002	0.019	0.002	0.012	0.001	0.000	0.000	0.000
Bear Wallow Wilderness	AZ	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Bitter Lake National Wildlife Refuge	NM	FWS	0.000	0.005	0.000	0.002	0.000	0.000	0.000	0.000
Blue Range Wilderness	NM	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Bosque Del Apache National Wildlife Refuge	NM	FWS	0.000	0.012	0.000	0.006	0.000	0.000	0.000	0.000
Browns Park National Wildlife Refuge	CO	FWS	0.000	0.005	0.000	0.001	0.000	0.000	0.000	0.000
Canyon de Chelly NM	AZ	NPS	0.001	0.031	0.001	0.022	0.000	0.000	0.000	0.000
Capitan Mountains Wilderness	NM	USFS	0.000	0.005	0.000	0.001	0.000	0.000	0.000	0.000
Chaco Culture NHP	NM	NPS	0.003	0.033	0.002	0.012	0.001	0.000	0.000	0.000
Chama River Canyon Wilderness	NM	USFS	0.028	0.109	0.016	0.032	0.005	0.001	0.001	0.000
Chimney Rock NM	CO	USFS	0.079	0.178	0.043	0.055	0.012	0.002	0.001	0.000
Colorado NM	CO	NPS	0.001	0.010	0.001	0.005	0.000	0.000	0.000	0.000
Cruces Basin Wilderness	NM	USFS	0.012	0.045	0.009	0.012	0.002	0.000	0.000	0.000
Curecanti NRA	CO	NPS	0.001	0.006	0.001	0.003	0.000	0.000	0.000	0.000
Dark Canyon Wilderness	UT	USFS	0.002	0.031	0.002	0.009	0.001	0.000	0.000	0.000
Dinosaur NM	CO	NPS	0.000	0.007	0.000	0.003	0.000	0.000	0.000	0.000
Dome Wilderness	NM	USFS	0.004	0.024	0.003	0.010	0.001	0.000	0.000	0.000
El Malpais NM	NM	NPS	0.001	0.014	0.001	0.004	0.000	0.000	0.000	0.000
Escudilla Wilderness	AZ	USFS	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000
Flaming Gorge	UT	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Florissant Fossil Beds NM	CO	NPS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000
Fossil Ridge Wilderness	CO	USFS	0.001	0.005	0.001	0.002	0.000	0.000	0.000	0.000
Glen Canyon NRA	UT	NPS	0.005	0.067	0.004	0.024	0.001	0.000	0.000	0.000
Great Sand Dunes National Park	CO	NPS	0.002	0.017	0.002	0.006	0.001	0.000	0.000	0.000
Great Sand Dunes National Preserve	CO	NPS	0.002	0.013	0.002	0.004	0.000	0.000	0.000	0.000
Greenhorn Mountain Wilderness	CO	USFS	0.001	0.009	0.001	0.002	0.000	0.000	0.000	0.000
High Uintas Wilderness	UT	USFS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Holy Cross Wilderness	CO	USFS	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000
Hovenweep NM	CO	NPS	0.007	0.056	0.005	0.019	0.002	0.000	0.000	0.000
Hunter-Fryingpan Wilderness	CO	USFS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000
Las Vegas National Wildlife Refuge	NM	FWS	0.001	0.012	0.001	0.005	0.000	0.000	0.000	0.000
Latir Peak Wilderness	NM	USFS	0.003	0.019	0.003	0.005	0.001	0.000	0.000	0.000
Lizard Head Wilderness	CO	USFS	0.003	0.013	0.002	0.004	0.001	0.000	0.000	0.000
Lost Creek Wilderness	CO	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Manzano Mountain Wilderness	NM	USFS	0.002	0.030	0.003	0.009	0.001	0.000	0.000	0.000

Class II	State	Owner	PSD Class II Increment[1]							
			25	30	17	9	4	512	91	20
Maxwell National Wildlife Refuge	NM	FWS	0.001	0.008	0.001	0.002	0.000	0.000	0.000	0.000
Monte Vista National Wildlife Refuge	CO	FWS	0.005	0.026	0.004	0.019	0.001	0.000	0.000	0.000
Mount Evans Wilderness	CO	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Mount Sneffels Wilderness	CO	USFS	0.002	0.011	0.001	0.003	0.000	0.000	0.000	0.000
Natural Bridges NM	UT	NPS	0.002	0.039	0.002	0.011	0.001	0.000	0.000	0.000
Navajo NM	AZ	NPS	0.000	0.029	0.000	0.008	0.000	0.000	0.000	0.000
Petroglyph NM	NM	NPS	0.002	0.027	0.002	0.013	0.001	0.000	0.000	0.000
Powderhorn Wilderness	CO	USFS	0.002	0.011	0.001	0.003	0.000	0.000	0.000	0.000
Raggeds Wilderness	CO	USFS	0.000	0.005	0.001	0.002	0.000	0.000	0.000	0.000
Rio Mora National Wildlife Refuge and Conservation Area	NM	FWS	0.001	0.011	0.001	0.004	0.000	0.000	0.000	0.000
Sandia Mountain Wilderness	NM	USFS	0.002	0.018	0.002	0.009	0.001	0.000	0.000	0.000
Sangre de Cristo Wilderness	CO	USFS	0.002	0.014	0.002	0.004	0.001	0.000	0.000	0.000
Savage Run Wilderness	WY	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Sevilleta National Wildlife Refuge	NM	FWS	0.001	0.016	0.001	0.009	0.000	0.000	0.000	0.000
South San Juan Wilderness	CO	USFS	0.028	0.081	0.019	0.025	0.005	0.001	0.000	0.000
Spanish Peaks Wilderness	CO	USFS	0.002	0.009	0.002	0.003	0.000	0.000	0.000	0.000
Uncompahgre Wilderness	CO	USFS	0.002	0.012	0.001	0.004	0.000	0.000	0.000	0.000
Valle De Oro National Wildlife Refuge	NM	FWS	0.002	0.026	0.002	0.014	0.001	0.000	0.000	0.000
Withington Wilderness	NM	USFS	0.000	0.006	0.000	0.002	0.000	0.000	0.000	0.000

Table 4-16. Contributions of FFO emissions to PSD pollutant concentrations at Class I areas for the 2025 Medium Development Scenario

		Pollutant	NO_2 ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)		$PM_{2.5}$ ($\mu g/m^3$)		SO_2 ($\mu g/m^3$)		
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.001	0.009	0.000	0.004	0.000	0.000	0.000	0.000
Bandelier Wilderness	NM	NPS	0.005	0.034	0.004	0.014	0.001	0.001	0.000	0.000
Black Canyon of the Gunnison Wilderness	CO	NPS	0.001	0.005	0.001	0.003	0.000	0.000	0.000	0.000
Bosque del Apache	NM	FWS	0.000	0.010	0.000	0.006	0.000	0.000	0.000	0.000
Canyonlands NP	UT	NPS	0.002	0.018	0.001	0.007	0.000	0.000	0.000	0.000
Capitol Reef NP	UT	NPS	0.001	0.013	0.000	0.005	0.000	0.000	0.000	0.000
Dinosaur NM	CO	NPS	0.000	0.005	0.000	0.003	0.000	0.000	0.000	0.000
Eagles Nest Wilderness	CO	USFS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Flat Tops Wilderness	CO	USFS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Gila Wilderness	NM	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Great Sand Dunes Wilderness-nps	CO	NPS	0.003	0.011	0.002	0.005	0.001	0.000	0.000	0.000
La Garita Wilderness	CO	USFS	0.003	0.011	0.002	0.005	0.001	0.000	0.000	0.000
Maroon Bells-Snowmass Wilderness	CO	USFS	0.001	0.004	0.000	0.002	0.000	0.000	0.000	0.000
Mesa Verde NP	**CO**	**NPS**	**0.019**	**0.076**	**0.009**	**0.033**	**0.003**	**0.002**	**0.001**	**0.000**
Mount Baldy Wilderness	AZ	USFS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Mount Zirkel Wilderness	CO	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Pecos Wilderness	NM	USFS	0.005	0.035	0.003	0.013	0.001	0.001	0.000	0.000
Petrified Forest NP	AZ	NPS	0.000	0.007	0.000	0.003	0.000	0.000	0.000	0.000
Rawah Wilderness	CO	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Rocky Mountain NP	CO	NPS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Salt Creek Wilderness	NM	FWS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000
San Pedro Parks Wilderness	NM	USFS	0.008	0.034	0.004	0.011	0.001	0.001	0.000	0.000
Weminuche Wilderness	CO	USFS	0.018	0.049	0.009	0.021	0.003	0.002	0.000	0.000
West Elk Wilderness	CO	USFS	0.001	0.005	0.001	0.003	0.000	0.000	0.000	0.000
Wheeler Peak Wilderness	NM	USFS	0.003	0.015	0.002	0.005	0.001	0.000	0.000	0.000
White Mountain Wilderness	NM	USFS	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000

Table 4-17. Contributions of FFO emissions to PSD pollutant concentrations at sensitive Class II areas for the 2025 Medium Development Scenario.

Pollutant			NO_2 (µg/m³)		PM_{10} (µg/m³)		PM_{25} (µg/m³)		SO_2 (µg/m³)	
Averaging Time			Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class II	State	Owner	PSD Class II Increment[1]							
			25	30	17	9	4	512	91	20
Alamosa National Wildlife Refuge	CO	FWS	0.004	0.025	0.003	0.016	0.001	0.000	0.000	0.000
Aldo Leopold Wilderness	NM	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Apache Kid Wilderness	NM	USFS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000
Aztec Ruins NM	**NM**	**NPS**	**0.947**	**0.862**	**0.324**	**0.316**	**0.095**	**0.012**	**0.008**	**0.003**
Baca National Wildlife Refuge	CO	FWS	0.003	0.018	0.002	0.013	0.001	0.000	0.000	0.000
Bear Wallow Wilderness	AZ	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Bitter Lake National Wildlife Refuge	NM	FWS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000
Blue Range Wilderness	NM	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Bosque Del Apache National Wildlife Refuge	NM	FWS	0.000	0.010	0.000	0.006	0.000	0.000	0.000	0.000
Browns Park National Wildlife Refuge	CO	FWS	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000
Canyon de Chelly NM	AZ	NPS	0.001	0.029	0.001	0.023	0.000	0.001	0.000	0.000
Capitan Mountains Wilderness	NM	USFS	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000
Chaco Culture NHP	NM	NPS	0.003	0.027	0.002	0.012	0.001	0.001	0.000	0.000
Chama River Canyon Wilderness	NM	USFS	0.032	0.087	0.013	0.032	0.005	0.002	0.001	0.000
Chimney Rock NM	CO	USFS	0.091	0.142	0.034	0.056	0.012	0.003	0.002	0.000
Colorado NM	CO	NPS	0.001	0.009	0.001	0.006	0.000	0.000	0.000	0.000
Cruces Basin Wilderness	NM	USFS	0.013	0.035	0.007	0.013	0.002	0.001	0.000	0.000
Curecanti NRA	CO	NPS	0.001	0.005	0.001	0.003	0.000	0.000	0.000	0.000
Dark Canyon Wilderness	UT	USFS	0.002	0.025	0.001	0.009	0.000	0.000	0.000	0.000
Dinosaur NM	CO	NPS	0.000	0.005	0.000	0.003	0.000	0.000	0.000	0.000
Dome Wilderness	NM	USFS	0.004	0.021	0.002	0.011	0.001	0.000	0.000	0.000
El Malpais NM	NM	NPS	0.001	0.011	0.000	0.005	0.000	0.000	0.000	0.000
Escudilla Wilderness	AZ	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Flaming Gorge	UT	USFS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Florissant Fossil Beds NM	CO	NPS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Fossil Ridge Wilderness	CO	USFS	0.001	0.005	0.001	0.003	0.000	0.000	0.000	0.000
Glen Canyon NRA	UT	NPS	0.005	0.053	0.003	0.024	0.001	0.001	0.000	0.000
Great Sand Dunes National Park	CO	NPS	0.003	0.014	0.002	0.007	0.001	0.000	0.000	0.000
Great Sand Dunes National Preserve	CO	NPS	0.002	0.010	0.001	0.004	0.001	0.000	0.000	0.000
Greenhorn Mountain Wilderness	CO	USFS	0.001	0.007	0.001	0.002	0.000	0.000	0.000	0.000
High Uintas Wilderness	UT	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Holy Cross Wilderness	CO	USFS	0.000	0.003	0.000	0.001	0.000	0.000	0.000	0.000
Hovenweep NM	CO	NPS	0.007	0.045	0.004	0.020	0.002	0.001	0.000	0.000
Hunter-Fryingpan Wilderness	CO	USFS	0.000	0.004	0.000	0.002	0.000	0.000	0.000	0.000
Las Vegas National Wildlife Refuge	NM	FWS	0.001	0.011	0.001	0.006	0.000	0.000	0.000	0.000
Latir Peak Wilderness	NM	USFS	0.003	0.015	0.002	0.005	0.001	0.000	0.000	0.000
Lizard Head Wilderness	CO	USFS	0.003	0.011	0.001	0.004	0.001	0.000	0.000	0.000

Pollutant			NO_2 (µg/m[3])		PM_{10} (µg/m[3])		PM_{25} (µg/m[3])		SO_2 (µg/m[3])	
Averaging Time			Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class II	State	Owner	PSD Class II Increment[1]							
			25	30	17	9	4	512	91	20
Lost Creek Wilderness	CO	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Manzano Mountain Wilderness	NM	USFS	0.002	0.024	0.002	0.009	0.001	0.001	0.000	0.000
Maxwell National Wildlife Refuge	NM	FWS	0.001	0.006	0.001	0.002	0.000	0.000	0.000	0.000
Monte Vista National Wildlife Refuge	CO	FWS	0.006	0.026	0.003	0.021	0.002	0.000	0.000	0.000
Mount Evans Wilderness	CO	USFS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Mount Sneffels Wilderness	CO	USFS	0.002	0.008	0.001	0.003	0.000	0.000	0.000	0.000
Natural Bridges NM	UT	NPS	0.003	0.031	0.001	0.011	0.001	0.001	0.000	0.000
Navajo NM	AZ	NPS	0.000	0.023	0.000	0.008	0.000	0.000	0.000	0.000
Petroglyph NM	NM	NPS	0.002	0.024	0.002	0.014	0.001	0.001	0.000	0.000
Powderhorn Wilderness	CO	USFS	0.002	0.009	0.001	0.003	0.000	0.000	0.000	0.000
Raggeds Wilderness	CO	USFS	0.001	0.004	0.000	0.002	0.000	0.000	0.000	0.000
Rio Mora National Wildlife Refuge and Conservation Area	NM	FWS	0.002	0.009	0.001	0.004	0.000	0.000	0.000	0.000
Sandia Mountain Wilderness	NM	USFS	0.002	0.016	0.001	0.010	0.001	0.000	0.000	0.000
Sangre de Cristo Wilderness	CO	USFS	0.003	0.012	0.002	0.004	0.001	0.000	0.000	0.000
Savage Run Wilderness	WY	USFS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Sevilleta National Wildlife Refuge	NM	FWS	0.001	0.015	0.001	0.009	0.000	0.000	0.000	0.000
South San Juan Wilderness	CO	USFS	0.033	0.065	0.015	0.027	0.005	0.002	0.001	0.000
Spanish Peaks Wilderness	CO	USFS	0.002	0.008	0.001	0.003	0.000	0.000	0.000	0.000
Uncompahgre Wilderness	CO	USFS	0.002	0.009	0.001	0.004	0.000	0.000	0.000	0.000
Valle De Oro National Wildlife Refuge	NM	FWS	0.002	0.024	0.002	0.015	0.001	0.000	0.000	0.000
Withington Wilderness	NM	USFS	0.000	0.005	0.000	0.002	0.000	0.000	0.000	0.000

5.0 VISIBILITY IMPACTS AT CLASS I/II AREAS USING "FLAG"

Visibility impacts were calculated for oil and gas emissions from the New Mexico FFO as well as for cumulative emissions sources. The approach uses incremental concentrations as quantified by the CAMx PSAT tool. Changes in light extinction from CAMx model concentration increments were calculated for each day at grid cells that intersect Class I and sensitive Class II areas within the 12/4 km modeling domain following Federal Land Managers Air Quality Related Values Work Group (FLAG) (2010) procedures.

The visibility evaluation metric used in this analysis is based on the Haze Index which is measured in deciview (dv) units and is defined as follows:

$$HI = 10 \text{ x } \ln[b_{ext}/10]$$

b_{ext} is the atmospheric light extinction measured in inverse megameters (Mm^{-1}) and is calculated primarily from atmospheric concentrations of particulates. A more intuitive measure of haze is visual range (VR), which is defined as the distance at which a large black object just disappears from view, and is measured in km. Visual range is related to b_{ext} by the formula VR = 3912 / b_{ext}. Visual range will not be used as a threshold in the analysis, but could be back-calculated from extinction to give a more easily understood visibility metric.

The incremental concentrations due to FFO area emissions were added to background concentrations in the extinction equation (b_{ext}) and the difference between the Haze Index with added FFO area concentrations to the Haze Index based solely on background concentrations was calculated. This quantity is the change in Haze Index, which is referred to as "delta deciview" (Δdv) :

$$\Delta dv = 10 \text{ x } \ln[b_{ext(BLM+background)}/10] - 10 \text{ x } \ln[b_{ext(background)}/10]$$

$$\Delta dv = 10 \text{ x } \ln[b_{ext(BLM+background)}/b_{ext(background)}]$$

Here $b_{ext(BLM+background)}$ refers to atmospheric light extinction due to oil and gas and other activities in the FFO area plus background concentrations, and $b_{ext(background)}$ refers to atmospheric light extinction due to background concentrations only.

For the FFO area, the estimated visibility degradation at the Class I areas and sensitive Class II areas due to new oil and gas emissions are presented in terms of the number of days that exceed a threshold change in deciview (Δdv) relative to background conditions. In the next section we describe the method for calculating the extinction, b_{ext}.

5.1 IMPROVE Reconstructed Mass Extinction Equations

The FLAG (2010) procedures for evaluating visibility impacts at Class I areas use the revised IMPROVE reconstructed mass extinction equation to convert PM species in μgm^{-3} to light extinction (b_{ext}) in inverse megameters (Mm^{-1}) as follows:

$$b_{ext} = b_{SO4} + b_{NO3} + b_{EC} + b_{OCM} + b_{Soil} + b_{PMC} + b_{SeaSalt} + b_{Rayleigh} + b_{NO2}$$

where

$$b_{SO4} = 2.2 \times f_S(RH) \times [\text{Small Sulfate}] + 4.8 \times f_L(RH) \times [\text{Large Sulfate}]$$

$$b_{NO3} = 2.4 \times f_S(RH) \times [\text{Small Nitrate}] + 5.1 \times f_L(RH) \times [\text{Large Nitrate}]$$

$$b_{OCM} = 2.8 \times [\text{Small Organic Mass}] + 6.1 \times [\text{Large Organic Mass}]$$

$$b_{EC} = 10 \times [\text{Elemental Carbon}]$$

$$b_{Soil} = 1 \times [\text{Fine Soil}]$$

$$b_{CM} = 0.6 \times [\text{Coarse Mass}]$$

$$b_{SeaSalt} = 1.7 \times f_{SS}(RH) \times [\text{Sea Salt}]$$

$$b_{Rayleigh} = \text{Rayleigh Scattering (Site-specific)}$$

$$b_{NO2} = 0.33 \times [NO_2\ (\text{ppb})]\ \{\text{or as: } 0.1755 \times [NO_2\ (\mu g/m^3)]\}.$$

f(RH) are relative humidity adjustment factors that account for the fact that sulfate, nitrate and sea salt aerosols are hygroscopic and are more effective at scattering radiation at higher relative humidity. FLAG (2010) recommends using monthly average f(RH) values rather than the hourly averages recommended in the previous FLAG (2000) guidance document in order to moderate the effects of extreme weather events on the visibility results.

The revised IMPROVE equation treats “large sulfate” and “small sulfate” separately because large and small aerosols affect an incoming beam of light differently. However, the IMPROVE measurements do not separately measure large and small sulfate; they measure only the total $PM_{2.5}$ sulfate. Similarly, CAMx writes out a single concentration of particulate sulfate for each grid cell. Part of the definition of the new IMPROVE equation is a procedure for calculating the large and small sulfate contributions based on the magnitude of the model output sulfate concentrations; the procedure is documented in FLAG (2010). The sulfate concentration magnitude is used as a surrogate for distinguishing between large and small sulfate concentrations. For a given grid cell, the large and small sulfate contributions are calculated from the model output sulfate (which is the “Total Sulfate” referred to in the FLAG (2010) guidance) as:

For Total Sulfate < 20 $\mu g/m^3$:

$$[\text{Large Sulfate}] = ([\text{Total Sulfate}] / 20\ \mu g/m^3) \times [\text{Total Sulfate}]$$

For Total Sulfate ≥ 20 $\mu g/m^3$:

$$[\text{Large Sulfate}] = [\text{Total Sulfate}]$$

For all values of Total Sulfate:

$$[\text{Small Sulfate}] = [\text{Total Sulfate}] - [\text{Large Sulfate}]$$

The procedure is identical for nitrate and organic mass. Sulfate, nitrate and organic mass concentrations for the western U.S. are expected to be mainly in the small fraction.

The PSAT source apportionment algorithm does not separately track NO_2 concentrations but instead tracks total reactive nitrogen (RGN) that consistent mainly of NO plus NO_2. Thus, for each hour and each grid cell representing a Class I/II area, a Source Group's incremental PSAT RGN contribution is converted to NO_2 by multiplying by the total (all emissions) CAMx model NO_2/RGN concentration ratio, which is then used in the IMPROVE visibility equation.

Although sodium and particulate chloride are treated in the CAMx core model, these species are not carried in the CAMx PSAT tool; neglecting sea salt in the visibility calculations in FFO impact assessment does not compromise the accuracy of the analysis as IMPROVE measurements show that sea salt concentrations are negligible in this inland area and there would be no sea salt associated with any of the oil and gas emissions.

Predicted daily average modeled concentrations due to the FFO area for grid cells containing Class I and sensitive Class II area receptors were processed using the revised IMPROVE reconstructed mass extinction equation FLAG (2010) to obtain changes in b_{ext} at each sensitive receptor area which are then converted to deciview and reported.

The FLAG (2010) method was used to estimate the visibility impacts from the FFO area. This method used the revised IMPROVE equation together with annual average natural conditions (see Table 6 in FLAG, 2010) and monthly relative humidity factors for each Class I area (see Tables 7-9 in FLAG, 2010). The Δdv was calculated for each grid cell that overlaps a Class I or sensitive Class II area for each day of the annual CAMx run. The highest Δdv across all grid cells overlapping a Class I or sensitive Class II area was selected to represent the daily value at that Class I/II area. Visibility impacts due to new oil and gas emissions from the FFO area that are more than 0.5 and 1.0 dv are reported.

5.2 FFO Contributions to Visibility Impairment at Class I and II Areas using FLAG (2010)

In this section, we present the visibility impacts at Class I and Class II areas due to Federal oil and gas emissions in the FFO for the 2025 High, Low and Medium Development Scenarios. Table 5-1 and

Table 5-2 display the maximum Δdv and number of days Δdv exceeds the 0.5 and 1.0 thresholds due to FFO emissions for all Class I and Class II areas, respectively, for the High Development Scenario. Table 5-3 and Table 5-4 display the equivalent results for the Low Development Scenario and Table 5-5 and Table 5-6 display the equivalent results for the Medium Development Scenario.

For the all three Development Scenarios, there are no days with Δdv > 0.5 at any Class I area due to emissions from the FFO and the only Class II area with days with Δdv > 0.5 is Aztec Ruins National Monument with Δdv summarized below:

- High Scenario has 261 days of Δdv > 0.5 and 80 days with Δdv > 1.0 and maximum Δdv of 2.66.
- Low Scenario has 82 days of Δdv > 0.5 and 6 days with Δdv > 1.0 and a maximum Δdv of 1.49.
- Medium Scenario has 84 days of Δdv > 0.5 and 9 days with Δdv > 1.0 and maximum Δdv of 1.55.

For the High Development Scenario, the maximum Δdv at a Class I area is at Mesa Verde NP, with Δdv = 0.39.

Table 5-1. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal oil and gas within the FFO Area (2025 High Development Scenario).

New Mexico Farmington Field Office				
			Number of Day	
Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I				
Arches NP	0.03212	12/12/2011	0	0
Bandelier Wilderness	0.11158	2/10/2011	0	0
Black Canyon of the Gunnison Wilderness	0.03077	12/3/2011	0	0
Bosque del Apache	0.04811	12/24/2011	0	0
Canyonlands NP	0.04789	12/11/2011	0	0
Capitol Reef NP	0.07101	12/11/2011	0	0
Dinosaur NM	0.01952	12/13/2011	0	0
Eagles Nest Wilderness	0.01554	12/11/2011	0	0
Flat Tops Wilderness	0.01127	12/11/2011	0	0
Gila Wilderness	0.01674	12/24/2011	0	0
Great Sand Dunes Wilderness-nps	0.05551	12/30/2011	0	0
La Garita Wilderness	0.04206	11/19/2011	0	0
Maroon Bells-Snowmass Wilderness	0.02339	3/19/2011	0	0
Mesa Verde NP	0.39291	12/10/2011	0	0
Mount Baldy Wilderness	0.00888	2/3/2011	0	0
Mount Zirkel Wilderness	0.01098	12/12/2011	0	0
Pecos Wilderness	0.13243	12/21/2011	0	0
Petrified Forest NP	0.02546	1/27/2011	0	0
Rawah Wilderness	0.00586	12/12/2011	0	0
Rocky Mountain NP	0.01433	12/12/2011	0	0
Salt Creek Wilderness	0.00962	2/11/2011	0	0
San Pedro Parks Wilderness	0.10555	2/3/2011	0	0
Weminuche Wilderness	0.18961	12/22/2011	0	0
West Elk Wilderness	0.02615	12/11/2011	0	0
Wheeler Peak Wilderness	0.03934	12/29/2011	0	0
White Mountain Wilderness	0.01089	1/16/2011	0	0

Note that the thresholds shown are project-level thresholds. The comparisons shown above are for informational purposes only.

Table 5-2. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class II area due to emissions from Federal oil and gas within the FFO Area (2025 High Development Scenario).

New Mexico Farmington Field Office				
			Number of Day	
Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class II				
Alamosa National Wildlife Refuge	0.23605	12/30/2011	0	0
Aldo Leopold Wilderness	0.01051	12/24/2011	0	0
Apache Kid Wilderness	0.01102	12/24/2011	0	0
Aztec Ruins NM	2.66071	1/7/2011	80	261
Baca National Wildlife Refuge	0.12384	12/30/2011	0	0
Bear Wallow Wilderness	0.00707	2/3/2011	0	0
Bitter Lake National Wildlife Refuge	0.00962	2/11/2011	0	0
Blue Range Wilderness	0.01145	12/24/2011	0	0
Bosque Del Apache National Wildlife Refuge	0.04811	12/24/2011	0	0
Browns Park National Wildlife Refuge	0.01565	12/12/2011	0	0
Canyon de Chelly NM	0.20695	12/18/2011	0	0
Capitan Mountains Wilderness	0.00899	1/16/2011	0	0
Chaco Culture NHP	0.10749	1/13/2011	0	0
Chama River Canyon Wilderness	0.23492	1/29/2011	0	0
Chimney Rock NM	0.37469	12/20/2011	0	0
Colorado NM	0.11858	12/11/2011	0	0
Cruces Basin Wilderness	0.16604	2/24/2011	0	0
Curecanti NRA	0.03375	12/11/2011	0	0
Dark Canyon Wilderness	0.05661	12/11/2011	0	0
Dinosaur NM	0.03534	12/12/2011	0	0
Dome Wilderness	0.10548	2/10/2011	0	0
El Malpais NM	0.04254	12/24/2011	0	0
Escudilla Wilderness	0.01211	12/24/2011	0	0
Flaming Gorge	0.01323	12/13/2011	0	0
Florissant Fossil Beds NM	0.02060	11/7/2011	0	0
Fossil Ridge Wilderness	0.02386	3/7/2011	0	0
Glen Canyon NRA	0.13996	12/10/2011	0	0
Great Sand Dunes National Park	0.10014	12/30/2011	0	0
Great Sand Dunes National Preserve	0.03048	3/6/2011	0	0
Greenhorn Mountain Wilderness	0.01866	11/12/2011	0	0
High Uintas Wilderness	0.01079	12/12/2011	0	0
Holy Cross Wilderness	0.01815	3/19/2011	0	0
Hovenweep NM	0.18390	12/10/2011	0	0
Hunter-Fryingpan Wilderness	0.01598	12/11/2011	0	0
Las Vegas National Wildlife Refuge	0.04965	12/21/2011	0	0
Latir Peak Wilderness	0.03491	1/4/2011	0	0
Lizard Head Wilderness	0.03225	3/19/2011	0	0
Lost Creek Wilderness	0.01726	3/19/2011	0	0
Manzano Mountain Wilderness	0.07242	12/25/2011	0	0
Maxwell National Wildlife Refuge	0.01722	11/15/2011	0	0
Monte Vista National Wildlife Refuge	0.19759	12/30/2011	0	0
Mount Evans Wilderness	0.01751	3/19/2011	0	0

New Mexico Farmington Field Office				
Class I&II Name	Δdv	Date	Number of Day	
			> 1.0	> 0.5
Class II				
Mount Sneffels Wilderness	0.02674	1/8/2011	0	0
Natural Bridges NM	0.06557	12/11/2011	0	0
Navajo NM	0.05209	12/17/2011	0	0
Petroglyph NM	0.12440	1/13/2011	0	0
Powderhorn Wilderness	0.03050	3/19/2011	0	0
Raggeds Wilderness	0.01669	3/6/2011	0	0
Rio Mora National Wildlife Refuge and Conservation Area	0.03564	10/29/2011	0	0
Sandia Mountain Wilderness	0.10919	1/13/2011	0	0
Sangre de Cristo Wilderness	0.03292	3/6/2011	0	0
Savage Run Wilderness	0.01106	12/12/2011	0	0
Sevilleta National Wildlife Refuge	0.07039	12/24/2011	0	0
South San Juan Wilderness	0.20681	12/21/2011	0	0
Spanish Peaks Wilderness	0.02811	10/31/2011	0	0
Uncompahgre Wilderness	0.03914	12/3/2011	0	0
Valle De Oro National Wildlife Refuge	0.17526	12/25/2011	0	0
Withington Wilderness	0.01584	12/24/2011	0	0

Table 5-3. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal oil and gas within the FFO Area (2025 Low Development Scenario).

New Mexico Farmington Field Office				
Class I&II Name	Δdv	Date	Number of Day > 1.0	Number of Day > 0.5
Class I				
Arches NP	0.01569	12/12/2011	0	0
Bandelier Wilderness	0.05591	2/10/2011	0	0
Black Canyon of the Gunnison Wilderness	0.01520	12/3/2011	0	0
Bosque del Apache	0.02396	12/24/2011	0	0
Canyonlands NP	0.02351	12/11/2011	0	0
Capitol Reef NP	0.03559	12/11/2011	0	0
Dinosaur NM	0.00966	12/13/2011	0	0
Eagles Nest Wilderness	0.00774	12/11/2011	0	0
Flat Tops Wilderness	0.00561	12/11/2011	0	0
Gila Wilderness	0.00826	12/24/2011	0	0
Great Sand Dunes Wilderness-nps	0.02764	12/30/2011	0	0
La Garita Wilderness	0.02117	11/19/2011	0	0
Maroon Bells-Snowmass Wilderness	0.01169	3/19/2011	0	0
Mesa Verde NP	0.20245	12/10/2011	0	0
Mount Baldy Wilderness	0.00448	2/3/2011	0	0
Mount Zirkel Wilderness	0.00547	12/12/2011	0	0
Pecos Wilderness	0.06774	12/21/2011	0	0
Petrified Forest NP	0.01275	1/27/2011	0	0
Rawah Wilderness	0.00287	12/12/2011	0	0
Rocky Mountain NP	0.00701	12/12/2011	0	0
Salt Creek Wilderness	0.00481	2/11/2011	0	0
San Pedro Parks Wilderness	0.05316	2/3/2011	0	0
Weminuche Wilderness	0.09989	12/22/2011	0	0
West Elk Wilderness	0.01323	12/11/2011	0	0
Wheeler Peak Wilderness	0.01969	12/29/2011	0	0
White Mountain Wilderness	0.00546	1/16/2011	0	0

Table 5-4. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class II area due to emissions from Federal oil and gas within the FFO Area (2025 Low Development Scenario).

New Mexico Farmington Field Office				
Class I&II Name	Δdv	Date	Number of Day > 1.0	Number of Day > 0.5
Class II				
Alamosa National Wildlife Refuge	0.11771	12/30/2011	0	0
Aldo Leopold Wilderness	0.00525	12/24/2011	0	0
Apache Kid Wilderness	0.00550	12/24/2011	0	0
Aztec Ruins NM	1.49245	1/7/2011	6	82
Baca National Wildlife Refuge	0.06182	12/30/2011	0	0
Bear Wallow Wilderness	0.00356	2/3/2011	0	0
Bitter Lake National Wildlife Refuge	0.00481	2/11/2011	0	0
Blue Range Wilderness	0.00570	12/24/2011	0	0
Bosque Del Apache National Wildlife Refuge	0.02396	12/24/2011	0	0
Browns Park National Wildlife Refuge	0.00777	12/12/2011	0	0
Canyon de Chelly NM	0.10263	12/18/2011	0	0
Capitan Mountains Wilderness	0.00450	1/16/2011	0	0
Chaco Culture NHP	0.05408	1/13/2011	0	0
Chama River Canyon Wilderness	0.11819	1/29/2011	0	0
Chimney Rock NM	0.19321	12/20/2011	0	0
Colorado NM	0.05287	12/11/2011	0	0
Cruces Basin Wilderness	0.08436	2/24/2011	0	0
Curecanti NRA	0.01657	12/11/2011	0	0
Dark Canyon Wilderness	0.02830	12/11/2011	0	0
Dinosaur NM	0.01762	12/12/2011	0	0
Dome Wilderness	0.05314	2/10/2011	0	0
El Malpais NM	0.02118	12/24/2011	0	0
Escudilla Wilderness	0.00603	12/24/2011	0	0
Flaming Gorge	0.00656	12/13/2011	0	0
Florissant Fossil Beds NM	0.01029	11/7/2011	0	0
Fossil Ridge Wilderness	0.01198	3/7/2011	0	0
Glen Canyon NRA	0.06999	12/10/2011	0	0
Great Sand Dunes National Park	0.05027	12/30/2011	0	0
Great Sand Dunes National Preserve	0.01513	3/6/2011	0	0
Greenhorn Mountain Wilderness	0.00920	11/12/2011	0	0
High Uintas Wilderness	0.00538	12/12/2011	0	0
Holy Cross Wilderness	0.00901	3/19/2011	0	0
Hovenweep NM	0.09470	12/10/2011	0	0
Hunter-Fryingpan Wilderness	0.00804	12/11/2011	0	0
Las Vegas National Wildlife Refuge	0.02443	12/21/2011	0	0
Latir Peak Wilderness	0.01768	1/4/2011	0	0
Lizard Head Wilderness	0.01630	3/19/2011	0	0
Lost Creek Wilderness	0.00867	3/19/2011	0	0
Manzano Mountain Wilderness	0.03619	12/25/2011	0	0
Maxwell National Wildlife Refuge	0.00855	11/15/2011	0	0
Monte Vista National Wildlife Refuge	0.09759	12/30/2011	0	0
Mount Evans Wilderness	0.00878	3/19/2011	0	0

New Mexico Farmington Field Office				
Class I&II Name	Δdv	Date	Number of Day > 1.0	Number of Day > 0.5
Class II				
Mount Sneffels Wilderness	0.01369	1/8/2011	0	0
Natural Bridges NM	0.03269	12/11/2011	0	0
Navajo NM	0.02603	12/17/2011	0	0
Petroglyph NM	0.06225	1/13/2011	0	0
Powderhorn Wilderness	0.01536	3/19/2011	0	0
Raggeds Wilderness	0.00839	12/11/2011	0	0
Rio Mora National Wildlife Refuge and Conservation Area	0.01769	10/29/2011	0	0
Sandia Mountain Wilderness	0.05463	1/13/2011	0	0
Sangre de Cristo Wilderness	0.01656	1/9/2011	0	0
Savage Run Wilderness	0.00567	12/12/2011	0	0
Sevilleta National Wildlife Refuge	0.03495	12/24/2011	0	0
South San Juan Wilderness	0.10500	12/21/2011	0	0
Spanish Peaks Wilderness	0.01395	10/31/2011	0	0
Uncompahgre Wilderness	0.02010	12/3/2011	0	0
Valle De Oro National Wildlife Refuge	0.08842	12/25/2011	0	0
Withington Wilderness	0.00790	12/24/2011	0	0

Table 5-5. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal oil and gas within the FFO Area (2025 Medium Development Scenario).

New Mexico Farmington Field Office				
			Number of Day	
Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I				
Arches NP	0.01720	12/12/2011	0	0
Bandelier Wilderness	0.06174	2/10/2011	0	0
Black Canyon of the Gunnison Wilderness	0.01719	12/3/2011	0	0
Bosque del Apache	0.02654	12/24/2011	0	0
Canyonlands NP	0.02483	12/11/2011	0	0
Capitol Reef NP	0.03675	12/11/2011	0	0
Dinosaur NM	0.01072	12/13/2011	0	0
Eagles Nest Wilderness	0.00851	12/11/2011	0	0
Flat Tops Wilderness	0.00586	12/11/2011	0	0
Gila Wilderness	0.00911	12/24/2011	0	0
Great Sand Dunes Wilderness-nps	0.03105	12/30/2011	0	0
La Garita Wilderness	0.02248	11/19/2011	0	0
Maroon Bells-Snowmass Wilderness	0.01284	3/19/2011	0	0
Mesa Verde NP	0.21445	12/10/2011	0	0
Mount Baldy Wilderness	0.00474	2/3/2011	0	0
Mount Zirkel Wilderness	0.00596	12/12/2011	0	0
Pecos Wilderness	0.06977	12/21/2011	0	0
Petrified Forest NP	0.01435	12/19/2011	0	0
Rawah Wilderness	0.00307	12/12/2011	0	0
Rocky Mountain NP	0.00794	12/12/2011	0	0
Salt Creek Wilderness	0.00482	2/11/2011	0	0
San Pedro Parks Wilderness	0.05498	2/3/2011	0	0
Weminuche Wilderness	0.10689	12/22/2011	0	0
West Elk Wilderness	0.01439	12/11/2011	0	0
Wheeler Peak Wilderness	0.02011	12/29/2011	0	0
White Mountain Wilderness	0.00556	1/16/2011	0	0

Table 5-6. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class II area due to emissions from Federal oil and gas within the FFO Area (2025 Medium Development Scenario).

New Mexico Farmington Field Office				
			Number of Day	
Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class II				
Alamosa National Wildlife Refuge	0.13285	12/30/2011	0	0
Aldo Leopold Wilderness	0.00555	12/24/2011	0	0
Apache Kid Wilderness	0.00587	12/24/2011	0	0
Aztec Ruins NM	1.54887	1/7/2011	9	84
Baca National Wildlife Refuge	0.06970	12/30/2011	0	0
Bear Wallow Wilderness	0.00369	2/3/2011	0	0
Bitter Lake National Wildlife Refuge	0.00482	2/11/2011	0	0
Blue Range Wilderness	0.00598	12/24/2011	0	0
Bosque Del Apache National Wildlife Refuge	0.02654	12/24/2011	0	0
Browns Park National Wildlife Refuge	0.00811	12/12/2011	0	0
Canyon de Chelly NM	0.11579	12/18/2011	0	0
Capitan Mountains Wilderness	0.00460	1/16/2011	0	0
Chaco Culture NHP	0.05898	1/13/2011	0	0
Chama River Canyon Wilderness	0.12511	12/9/2011	0	0
Chimney Rock NM	0.20171	12/20/2011	0	0
Colorado NM	0.06460	12/11/2011	0	0
Cruces Basin Wilderness	0.09269	2/24/2011	0	0
Curecanti NRA	0.01874	12/11/2011	0	0
Dark Canyon Wilderness	0.02841	12/11/2011	0	0
Dinosaur NM	0.01961	12/12/2011	0	0
Dome Wilderness	0.05841	2/10/2011	0	0
El Malpais NM	0.02280	12/24/2011	0	0
Escudilla Wilderness	0.00626	12/24/2011	0	0
Flaming Gorge	0.00734	12/13/2011	0	0
Florissant Fossil Beds NM	0.01132	11/7/2011	0	0
Fossil Ridge Wilderness	0.01326	3/7/2011	0	0
Glen Canyon NRA	0.07143	12/10/2011	0	0
Great Sand Dunes National Park	0.05621	12/30/2011	0	0
Great Sand Dunes National Preserve	0.01628	3/6/2011	0	0
Greenhorn Mountain Wilderness	0.00943	11/12/2011	0	0
High Uintas Wilderness	0.00570	12/12/2011	0	0
Holy Cross Wilderness	0.00990	3/19/2011	0	0
Hovenweep NM	0.10168	12/10/2011	0	0
Hunter-Fryingpan Wilderness	0.00871	12/11/2011	0	0
Las Vegas National Wildlife Refuge	0.02753	12/21/2011	0	0
Latir Peak Wilderness	0.01870	1/4/2011	0	0
Lizard Head Wilderness	0.01733	3/19/2011	0	0
Lost Creek Wilderness	0.00945	3/19/2011	0	0
Manzano Mountain Wilderness	0.04036	12/25/2011	0	0
Maxwell National Wildlife Refuge	0.00891	11/15/2011	0	0
Monte Vista National Wildlife Refuge	0.11085	12/30/2011	0	0
Mount Evans Wilderness	0.00963	3/19/2011	0	0

New Mexico Farmington Field Office				
Class I&II Name	Δdv	Date	Number of Day > 1.0	Number of Day > 0.5
Class II				
Mount Sneffels Wilderness	0.01407	1/8/2011	0	0
Natural Bridges NM	0.03274	12/11/2011	0	0
Navajo NM	0.02555	12/17/2011	0	0
Petroglyph NM	0.06912	1/13/2011	0	0
Powderhorn Wilderness	0.01624	3/19/2011	0	0
Raggeds Wilderness	0.00915	3/6/2011	0	0
Rio Mora National Wildlife Refuge and Conservation Area	0.01810	10/29/2011	0	0
Sandia Mountain Wilderness	0.06052	1/13/2011	0	0
Sangre de Cristo Wilderness	0.01758	3/6/2011	0	0
Savage Run Wilderness	0.00601	12/12/2011	0	0
Sevilleta National Wildlife Refuge	0.03896	12/24/2011	0	0
South San Juan Wilderness	0.11154	12/21/2011	0	0
Spanish Peaks Wilderness	0.01372	10/31/2011	0	0
Uncompahgre Wilderness	0.02221	12/3/2011	0	0
Valle De Oro National Wildlife Refuge	0.09894	12/25/2011	0	0
Withington Wilderness	0.00841	12/24/2011	0	0

5.3 Cumulative Visibility

In CARMMS 2.0, the cumulative visibility impacts due to development of oil and gas and other (e.g., mining) activities on all BLM Planning Areas were assessed following the recommendations from the FWS and NPS that was outlined in their February 10, 2012 letter to the Wyoming Department of Environmental Quality on recommended cumulative visibility method for the Continental Divide-Creston gas infill development EIS (FWS and NPS, 2012) and subsequent conversations with the FLMs. This approach is based on an abbreviated regional haze rule method that estimates the future year visibility at Class I and sensitive Class II areas for the average of the Worst 20 % (W20%) and Best 20 % (B20%) visibility days with and without the effects of the cumulative emissions on visibility impairment. The cumulative visibility impacts used CAMx model output from the 2011 Base Case and 2025 emissions scenarios in conjunction with monitoring data to produce cumulative visibility impacts at each Class I area in the CARMMS domain. EPA's Modeled Attainment Test Software (MATS[6]) was used to make the 2025 visibility projections for the W20% and B20% days. The basic steps in the recommended cumulative visibility method are as follows (FWS and NPS, 2012):

1. Calculate the observed average 2011 current year cumulative visibility impact using the Haze Index (HI, in deciviews) at each Class I or associated sensitive Class II area to determine the 20% of days with the worst and 20% of days with the best visibility. The intent is to incorporate 5 years of monitoring data surrounding the 2011 Base Case year, which would include 2009-2013. MATS uses the IMPROVE data associated

[6] http://www.epa.gov/ttn/scram/modelingapps_mats.htm

with each Class I area and modeling results at the location of the IMPROVE monitoring site.

2. Estimate the relative response factors (RRFs) for each component of $PM_{2.5}$ and for coarse mass (CM) corresponding to the new IMPROVE visibility algorithm using the CAMx 2011 and 2025 model output.

3. Using the RRFs and ambient data, calculate 2025 future-year daily concentration data for the B20% and W20% days using the CAMx 2011 Base Case and 2025 standard model concentration estimates and PSAT source apportionment modeling results two ways:

4. <u>2025 Total Emissions</u>: Use total 2025 High, Low and Medium Development Scenario CAMx concentration results due to all emissions;

5. <u>2025 No Cumulative Emissions</u>: Use PSAT source apportionment results to eliminate contributions of PM concentrations associated with combined emission scenarios.

6. Use the information in step 3 to calculate the average 2025 visibility for the 20% Best and 20% Worst visibility days and the 2025 emissions.

7. Assess the average differences in cumulative visibility impacts for the combined scenarios and also compare with the current observed Baseline visibility conditions.

Since FFO cumulative impacts (i.e. impacts from the FFO and other oil and gas Development sources) were not quantified together as a combined emissions scenario in CARMMS, it is not possible to assess the FFO cumulative visibility impact. However, the FFO emissions are included in the 2025 Total Emissions (for each Scenario). Therefore, in this section, we present MATS visibility results for 2011 Baseline and 2025 Development Scenarios (i.e. we omit steps 5 and 7 from the list above).

Table 5-7, Table 5-8, and Table 5-9 present the MATS visibility results for the High, Low, and Medium Development Scenarios respectively. For both W20% days and B20% days, visibility is predicted to be generally better in the year 2025 than it was in 2011, even for the High Development Scenario which on average reports a 0.22 dv improvement on W20% days and a 0.15 dv improvement on B20% days. The visibility improvement is likely attributable to emissions reductions in non-oil and gas anthropogenic source categories.

Table 5-7. MATS cumulative visibility impacts for the High Development Scenario.

			Worst 20% Visibility (dv)		Best 20% Visibility (dv)	
Class I Name	**State**	**IMPROVE Site**	**2011 Base**	**2025 High**	**2011 Base**	**2025 High**
Arches NP	UT	CANY1	10.83	10.63	3.06	2.91
Mount Baldy Wilderness	AZ	BALD1	10.53	9.98	2.73	2.56
Bandelier NM	NM	BAND1	11.92	11.85	3.99	3.81
Black Canyon of the Gunnison NM	CO	WEMI1	9.77	9.55	2.06	1.89
Bosque del Apache	NM	BOAP1	14.02	13.56	5.72	5.50
Canyonlands NP	AZ	PEFO1	11.92	11.24	4.08	3.62
Capitol Reef NP	NM	WHIT1	14.19	14.22	3.34	3.25
Eagles Nest Wilderness	CO	WHRI1	8.47	8.24	0.51	0.32
Flat Tops Wilderness	CO	WHRI1	8.47	8.24	0.51	0.32
Gila Wilderness	NM	GICL1	11.19	10.85	2.46	2.41
Great Sand Dunes NM	CO	GRSA1	11.57	11.43	3.81	3.69
La Garita Wilderness	CO	WEMI1	9.77	9.55	2.06	1.89
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.47	8.24	0.51	0.32
Mesa Verde NP	CO	MEVE1	11.22	11.18	2.97	2.78
Mount Zirkel Wilderness	CO	MOZI1	9.13	8.97	0.89	0.81
Pecos Wilderness	NM	WHPE1	9.90	9.68	4.08	3.62
Petrified Forest NP	AZ	PEFO1	11.92	11.24	1.09	1.08
Rawah Wilderness	CO	MOZI1	9.13	8.97	0.89	0.81
Rocky Mountain NP	CO	ROMO1	11.84	11.93	1.61	1.47
Salt Creek	NM	SACR1	17.42	17.53	7.37	7.38
San Pedro Parks Wilderness	NM	SAPE1	9.86	9.56	1.42	1.33
West Elk Wilderness	CO	WHRI1	8.47	8.24	0.51	0.32
Weminuche Wilderness	CO	WEMI1	9.77	9.55	2.06	1.89
Wheeler Peak Wilderness	NM	WHPE1	9.90	9.68	1.09	1.08

			Worst 20% Visibility (dv)		Best 20% Visibility (dv)	
Class I Name	**State**	**IMPROVE Site**	**2011 Base**	**2025 High**	**2011 Base**	**2025 High**
White Mountain Wilderness	NM	WHIT1	14.19	14.22	3.34	3.25
Dinosaur NM	CO	MOZI1	9.13	8.97	0.89	0.81

Table 5-8. MATS cumulative visibility impacts for the Low Development Scenario.

			Worst 20% Visibility (dv)		Best 20% Visibility (dv)	
Class I Name	**State**	**IMPROVE Site**	**2011 Base**	**2025 Low**	**2011 Base**	**2025 Low**
Arches NP	UT	CANY1	10.83	10.41	3.06	2.87
Mount Baldy Wilderness	AZ	BALD1	10.53	9.98	2.73	2.56
Bandelier NM	NM	BAND1	11.92	11.84	3.99	3.80
Black Canyon of the Gunnison NM	CO	WEMI1	9.77	9.53	2.06	1.86
Bosque del Apache	NM	BOAP1	14.02	13.55	5.72	5.49
Canyonlands NP	AZ	PEFO1	11.92	11.24	4.08	3.61
Capitol Reef NP	NM	WHIT1	14.19	14.22	3.34	3.25
Eagles Nest Wilderness	CO	WHRI1	8.47	8.19	0.51	0.26
Flat Tops Wilderness	CO	WHRI1	8.47	8.19	0.51	0.26
Gila Wilderness	NM	GICL1	11.19	10.85	2.46	2.41
Great Sand Dunes NM	CO	GRSA1	11.57	11.40	3.81	3.64
La Garita Wilderness	CO	WEMI1	9.77	9.53	2.06	1.86
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.47	8.19	0.51	0.26
Mesa Verde NP	CO	MEVE1	11.22	11.13	2.97	2.72
Mount Zirkel Wilderness	CO	MOZI1	9.13	8.86	0.89	0.76
Pecos Wilderness	NM	WHPE1	9.90	9.67	4.08	3.61
Petrified Forest NP	AZ	PEFO1	11.92	11.24	1.09	1.06
Rawah Wilderness	CO	MOZI1	9.13	8.86	0.89	0.76
Rocky Mountain NP	CO	ROMO1	11.84	11.63	1.61	1.43
Salt Creek	NM	SACR1	17.42	17.53	7.37	7.38
San Pedro Parks Wilderness	NM	SAPE1	9.86	9.56	1.42	1.31
West Elk Wilderness	CO	WHRI1	8.47	8.19	0.51	0.26
Weminuche Wilderness	CO	WEMI1	9.77	9.53	2.06	1.86
Wheeler Peak Wilderness	NM	WHPE1	9.90	9.67	1.09	1.06
White Mountain Wilderness	NM	WHIT1	14.19	14.22	3.34	3.25
Dinosaur NM	CO	MOZI1	9.13	8.86	0.89	0.76

Table 5-9. MATS cumulative visibility impacts for the Medium Development Scenario.

			Worst 20% Visibility (dv)		Best 20% Visibility (dv)	
Class I Name	**State**	**IMPROVE Site**	**2011 Base**	**2025 Medium**	**2011 Base**	**2025 Medium**
Arches NP	UT	CANY1	10.83	10.60	3.06	2.90
Mount Baldy Wilderness	AZ	BALD1	10.53	9.98	2.73	2.56
Bandelier NM	NM	BAND1	11.92	11.85	3.99	3.81
Black Canyon of the Gunnison NM	CO	WEMI1	9.77	9.54	2.06	1.88
Bosque del Apache	NM	BOAP1	14.02	13.56	5.72	5.49
Canyonlands NP	AZ	PEFO1	11.92	11.24	4.08	3.62
Capitol Reef NP	NM	WHIT1	14.19	14.22	3.34	3.25
Eagles Nest Wilderness	CO	WHRI1	8.47	8.23	0.51	0.31
Flat Tops Wilderness	CO	WHRI1	8.47	8.23	0.51	0.31
Gila Wilderness	NM	GICL1	11.19	10.85	2.46	2.41
Great Sand Dunes NM	CO	GRSA1	11.57	11.42	3.81	3.68
La Garita Wilderness	CO	WEMI1	9.77	9.54	2.06	1.88
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.47	8.23	0.51	0.31
Mesa Verde NP	CO	MEVE1	11.22	11.15	2.97	2.75
Mount Zirkel Wilderness	CO	MOZI1	9.13	8.95	0.89	0.80
Pecos Wilderness	NM	WHPE1	9.90	9.68	4.08	3.62
Petrified Forest NP	AZ	PEFO1	11.92	11.24	1.09	1.07
Rawah Wilderness	CO	MOZI1	9.13	8.95	0.89	0.80
Rocky Mountain NP	CO	ROMO1	11.84	11.92	1.61	1.47
Salt Creek	NM	SACR1	17.42	17.53	7.37	7.38
San Pedro Parks Wilderness	NM	SAPE1	9.86	9.56	1.42	1.32
West Elk Wilderness	CO	WHRI1	8.47	8.23	0.51	0.31
Weminuche Wilderness	CO	WEMI1	9.77	9.54	2.06	1.88
Wheeler Peak Wilderness	NM	WHPE1	9.90	9.68	1.09	1.07
White Mountain Wilderness	NM	WHIT1	14.19	14.22	3.34	3.25
Dinosaur NM	CO	MOZI1	9.13	8.95	0.89	0.80

6.0 SULFUR AND NITROGEN DEPOSITION

CAMx-predicted wet and dry fluxes of sulfur- and nitrogen-containing species were processed to estimate total annual sulfur (S) and nitrogen (N) deposition values at each Class I and sensitive Class II area. The maximum annual S and N deposition values from any grid cell that intersects a Class I or sensitive Class II receptor area was used to represent deposition for that area, in addition to the average annual deposition values of all grid cells that intersect a Class I or sensitive Class II receptor area. Predicted maximum and average annual S and N deposition impacts due to FFO area emissions are reported.

Nitrogen deposition impacts were calculated by taking the sum of the nitrogen contained in the fluxes of all nitrogen species modeled by the CAMx PSAT source apportionment tool. CAMx species used in the nitrogen deposition flux calculation are: reactive gaseous nitrate species, RGN (NO, NO_2, NO_3 radical, HONO, N_2O_5), TPN (PAN, PANX, PNA), organic nitrates (NTR), particulate nitrate formed from primary emissions plus secondarily formed particulate nitrate (NO_3), gaseous nitric acid (HNO_3), gaseous ammonia (NH_3) and particulate ammonium (NH_4). CAMx species used in the sulfur deposition calculation are primarily sulfur dioxide emissions (SO_2) and particulate sulfate ion from primary emissions plus secondarily formed sulfate (SO_4).

FLAG (2010) recommends that applicable sources assess impacts of nitrogen and sulfur deposition at Class I areas. This guidance recognizes the importance of establishing critical deposition loading values ("Critical Loads") for each specific Class I area as these Critical Loads are completely dependent on local atmospheric, aquatic and terrestrial conditions and chemistry. Critical Load thresholds are essentially a level of atmospheric pollutant deposition below which negative ecosystem effects are not likely to occur. FLAG (2010) does not include any Critical Load levels for specific Class I areas and refers to site-specific critical load information on FLM websites for each area of concern. This guidance does, however recommend the use of deposition analysis thresholds (DATs[7]) developed by the National Park Service and the Fish and Wildlife Service. The DATs represent screening level values for nitrogen and sulfur deposition for individual projects with deposition impacts below the DATS considered negligible. Note that DATs are Project-level thresholds. DAT have been established for both nitrogen and sulfur deposition and in western Class I areas they are 0.005 kilograms per hectare per year (kg/ha-yr) for both nitrogen and sulfur deposition. As a screening analysis, results for oil and gas activities of the FFO was compared to the DATs.

For the 2025 total emissions, the annual nitrogen and sulfur deposition were compared against Critical Load values established for the Rocky Mountain region to assess total deposition impacts. The NPS has provided recent information on nitrogen critical load values applicable for Wyoming and Colorado Class I and sensitive Class II areas (NPS, 2014). For Class I and sensitive Class II areas in Wyoming a critical load value of 2.2 kg/ha-yr for nitrogen deposition (estimated from a wet deposition critical load value of 1.4 kg N/ha-yr) is applicable, based on research conducted by Saros et. al. (2010) in the eastern Sierra Nevada and Greater Yellowstone ecosystems. This is a critical load value that is protective of high elevation surface waters. For

[7] http://www.nature.nps.gov/air/Pubs/pdf/flag/nsDATGuidance.pdf

Colorado Class I and sensitive Class II areas (with the exception of Dinosaur National Monument) a critical load value 2.3 kg N/ha-yr is applicable for total nitrogen deposition, based on research conducted by Jill Baron (Baron 2006) that estimated 1.5 kg/ha-yr as a critical loading value for wet nitrogen deposition for high-elevation lakes in Rocky Mountain National Park, Colorado. For Dinosaur National Monument, which is an arid region, a nitrogen deposition critical load value is based on research conducted by Pardo et al. (2011) which concluded that the cumulative critical load necessary to protect shrublands and lichen communities in Dinosaur NM is 3 kg N/ha/year.

For sulfur deposition, the critical load threshold published by Fox et al. (Fox 1989) for total sulfur deposition of 5 kg/ha-yr, for the Bob Marshall Wilderness Area in Montana and Bridger Wilderness Area in Wyoming, was used as critical load threshold for each of the Class I and sensitive Class II areas.

In summary, we compare the 2025 total annual sulfur and nitrogen deposition amounts to the following Critical Load values:

Nitrogen

- Wyoming – 2.2 kg/ha-yr
- Colorado – 2.3 kg/ha-yr, except for Dinosaur Monument that will use 3.0 kg/ha-yr

Sulfur

- 5.0 kg/ha-yr – all areas

6.1 Sulfur and Nitrogen Deposition from New Mexico FFO emissions at Class I and Sensitive Class II Areas

Table 6-1 and Table 6-2 report sulfur and nitrogen deposition due to emissions from the FFO for the High Development Scenario for Class I and Class II areas, respectively.

Table 6-3 and Table 6-4, report the analogous results for the Low Development Scenario and Table 6-5 and Table 6-6 report the Medium Development Scenario results.

Sulfur deposition at all Class I and Class II areas is well below the DATs. For the High Development Scenario, nitrogen deposition at some Class I and Class II areas located close to the FFO exceed the DATs. The highest Class I area deposition is at Mesa Verde with maximum nitrogen deposition of 0.0345 kgN/ha and average nitrogen deposition of 0.0271 kgN/ha. The highest Class II area deposition is at Aztec Ruins NM with maximum nitrogen deposition of 0.1413 kgN/ha and average nitrogen deposition of 0.1376 kgN/ha.

For the Low Development Scenario, the nitrogen deposition is lower than for the High Development Scenario but still exceeds the DATs at some Class I and Class II areas. In particular, the highest deposition Class I area is still Mesa Verde, with maximum and average nitrogen deposition for Mesa Verde, of 0.0172 kgN/ha and 0.0134 kgN/ha, respectively.

Table 6-1. FFO sulfur and nitrogen deposition Impacts at Class I areas for High Development Scenario.

Class I Area	New Mexico Farmington Field Office			
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Arches NP	0.0021	0.0018	0.0000	0.0000
Bandelier Wilderness	0.0074	0.0067	0.0001	0.0000
Black Canyon of the Gunnison Wilderness	0.0035	0.0031	0.0000	0.0000
Bosque del Apache	0.0010	0.0008	0.0000	0.0000
Canyonlands NP	0.0051	0.0020	0.0000	0.0000
Capitol Reef NP	0.0012	0.0006	0.0000	0.0000
Dinosaur NM	0.0008	0.0005	0.0000	0.0000
Eagles Nest Wilderness	0.0020	0.0016	0.0000	0.0000
Flat Tops Wilderness	0.0018	0.0014	0.0000	0.0000
Gila Wilderness	0.0003	0.0002	0.0000	0.0000
Great Sand Dunes Wilderness-nps	0.0085	0.0069	0.0001	0.0001
La Garita Wilderness	0.0089	0.0072	0.0001	0.0001
Maroon Bells-Snowmass Wilderness	0.0032	0.0025	0.0001	0.0000
Mesa Verde NP	0.0345	0.0271	0.0002	0.0002
Mount Baldy Wilderness	0.0003	0.0003	0.0000	0.0000
Mount Zirkel Wilderness	0.0013	0.0010	0.0000	0.0000
Pecos Wilderness	0.0111	0.0082	0.0001	0.0001
Petrified Forest NP	0.0004	0.0003	0.0000	0.0000
Rawah Wilderness	0.0013	0.0011	0.0000	0.0000
Rocky Mountain NP	0.0015	0.0011	0.0000	0.0000
Salt Creek Wilderness	0.0008	0.0007	0.0000	0.0000
San Pedro Parks Wilderness	0.0120	0.0091	0.0001	0.0001
Weminuche Wilderness	0.0328	0.0161	0.0006	0.0003
West Elk Wilderness	0.0034	0.0027	0.0001	0.0000
Wheeler Peak Wilderness	0.0100	0.0084	0.0001	0.0001
White Mountain Wilderness	0.0010	0.0009	0.0000	0.0000

Table 6-2. FFO sulfur and nitrogen deposition Impacts at Class II areas for High Development Scenario.

Class II Area	New Mexico Farmington Field Office			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Alamosa National Wildlife Refuge	0.0086	0.0080	0.0001	0.0001
Aldo Leopold Wilderness	0.0004	0.0003	0.0000	0.0000
Apache Kid Wilderness	0.0005	0.0005	0.0000	0.0000
Aztec Ruins NM	0.1413	0.1376	0.0017	0.0016
Baca National Wildlife Refuge	0.0070	0.0059	0.0001	0.0000
Bear Wallow Wilderness	0.0002	0.0002	0.0000	0.0000
Bitter Lake National Wildlife Refuge	0.0008	0.0006	0.0000	0.0000
Blue Range Wilderness	0.0004	0.0003	0.0000	0.0000
Bosque Del Apache National Wildlife Refuge	0.0010	0.0008	0.0000	0.0000
Browns Park National Wildlife Refuge	0.0003	0.0003	0.0000	0.0000
Canyon de Chelly NM	0.0014	0.0010	0.0000	0.0000
Capitan Mountains Wilderness	0.0011	0.0010	0.0000	0.0000
Chaco Culture NHP	0.0045	0.0039	0.0000	0.0000
Chama River Canyon Wilderness	0.0364	0.0247	0.0003	0.0002
Chimney Rock NM	0.0721	0.0721	0.0005	0.0005
Colorado NM	0.0024	0.0022	0.0000	0.0000
Cruces Basin Wilderness	0.0277	0.0237	0.0004	0.0003
Curecanti NRA	0.0033	0.0025	0.0000	0.0000
Dark Canyon Wilderness	0.0063	0.0049	0.0000	0.0000
Dinosaur NM	0.0008	0.0005	0.0000	0.0000
Dome Wilderness	0.0066	0.0063	0.0000	0.0000
El Malpais NM	0.0017	0.0010	0.0000	0.0000
Escudilla Wilderness	0.0004	0.0004	0.0000	0.0000
Flaming Gorge	0.0005	0.0002	0.0000	0.0000
Florissant Fossil Beds NM	0.0022	0.0021	0.0000	0.0000
Fossil Ridge Wilderness	0.0038	0.0033	0.0001	0.0000
Glen Canyon NRA	0.0114	0.0019	0.0001	0.0000
Great Sand Dunes National Park	0.0088	0.0070	0.0001	0.0001
Great Sand Dunes National Preserve	0.0096	0.0084	0.0001	0.0001
Greenhorn Mountain Wilderness	0.0068	0.0060	0.0001	0.0001
High Uintas Wilderness	0.0003	0.0002	0.0000	0.0000
Holy Cross Wilderness	0.0021	0.0018	0.0000	0.0000
Hovenweep NM	0.0131	0.0125	0.0001	0.0001

Class II Area	New Mexico Farmington Field Office			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Hunter-Fryingpan Wilderness	0.0026	0.0021	0.0000	0.0000
Las Vegas National Wildlife Refuge	0.0036	0.0029	0.0000	0.0000
Latir Peak Wilderness	0.0096	0.0084	0.0001	0.0001
Lizard Head Wilderness	0.0096	0.0086	0.0002	0.0001
Lost Creek Wilderness	0.0025	0.0021	0.0000	0.0000
Manzano Mountain Wilderness	0.0068	0.0056	0.0000	0.0000
Maxwell National Wildlife Refuge	0.0032	0.0028	0.0000	0.0000
Monte Vista National Wildlife Refuge	0.0098	0.0081	0.0001	0.0001
Mount Evans Wilderness	0.0020	0.0018	0.0000	0.0000
Mount Sneffels Wilderness	0.0075	0.0067	0.0002	0.0001
Natural Bridges NM	0.0063	0.0056	0.0000	0.0000
Navajo NM	0.0009	0.0009	0.0000	0.0000
Petroglyph NM	0.0036	0.0034	0.0000	0.0000
Powderhorn Wilderness	0.0067	0.0057	0.0001	0.0001
Raggeds Wilderness	0.0027	0.0023	0.0000	0.0000
Rio Mora National Wildlife Refuge and Conservation Area	0.0043	0.0037	0.0000	0.0000
Sandia Mountain Wilderness	0.0062	0.0043	0.0000	0.0000
Sangre de Cristo Wilderness	0.0111	0.0072	0.0002	0.0001
Savage Run Wilderness	0.0007	0.0006	0.0000	0.0000
Sevilleta National Wildlife Refuge	0.0023	0.0015	0.0000	0.0000
South San Juan Wilderness	0.0482	0.0341	0.0007	0.0005
Spanish Peaks Wilderness	0.0084	0.0078	0.0001	0.0001
Uncompahgre Wilderness	0.0075	0.0052	0.0001	0.0001
Valle De Oro National Wildlife Refuge	0.0021	0.0021	0.0000	0.0000
Withington Wilderness	0.0006	0.0005	0.0000	0.0000

Table 6-3. FFO sulfur and nitrogen deposition Impacts at Class I areas for Low Development Scenario

Class I Area	New Mexico Farmington Field Office			
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Arches NP	0.0010	0.0009	0.0000	0.0000
Bandelier Wilderness	0.0037	0.0033	0.0000	0.0000
Black Canyon of the Gunnison Wilderness	0.0017	0.0015	0.0000	0.0000
Bosque del Apache	0.0005	0.0004	0.0000	0.0000
Canyonlands NP	0.0025	0.0010	0.0000	0.0000
Capitol Reef NP	0.0006	0.0003	0.0000	0.0000
Dinosaur NM	0.0004	0.0003	0.0000	0.0000
Eagles Nest Wilderness	0.0010	0.0008	0.0000	0.0000
Flat Tops Wilderness	0.0009	0.0007	0.0000	0.0000
Gila Wilderness	0.0002	0.0001	0.0000	0.0000
Great Sand Dunes Wilderness-nps	0.0042	0.0034	0.0000	0.0000
La Garita Wilderness	0.0044	0.0036	0.0001	0.0001
Maroon Bells-Snowmass Wilderness	0.0016	0.0012	0.0000	0.0000
Mesa Verde NP	0.0172	0.0134	0.0001	0.0001
Mount Baldy Wilderness	0.0001	0.0001	0.0000	0.0000
Mount Zirkel Wilderness	0.0006	0.0005	0.0000	0.0000
Pecos Wilderness	0.0055	0.0040	0.0001	0.0000
Petrified Forest NP	0.0002	0.0002	0.0000	0.0000
Rawah Wilderness	0.0007	0.0006	0.0000	0.0000
Rocky Mountain NP	0.0007	0.0005	0.0000	0.0000
Salt Creek Wilderness	0.0004	0.0004	0.0000	0.0000
San Pedro Parks Wilderness	0.0060	0.0045	0.0000	0.0000
Weminuche Wilderness	0.0163	0.0080	0.0003	0.0002
West Elk Wilderness	0.0017	0.0013	0.0000	0.0000
Wheeler Peak Wilderness	0.0050	0.0042	0.0001	0.0000
White Mountain Wilderness	0.0005	0.0004	0.0000	0.0000

Table 6-4. FFO sulfur and nitrogen deposition Impacts at Class II areas for Low Development Scenario.

Class II Area	New Mexico Farmington Field Office			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Alamosa National Wildlife Refuge	0.0043	0.0040	0.0000	0.0000
Aldo Leopold Wilderness	0.0002	0.0001	0.0000	0.0000
Apache Kid Wilderness	0.0003	0.0002	0.0000	0.0000
Aztec Ruins NM	0.0712	0.0694	0.0008	0.0008
Baca National Wildlife Refuge	0.0034	0.0029	0.0000	0.0000
Bear Wallow Wilderness	0.0001	0.0001	0.0000	0.0000
Bitter Lake National Wildlife Refuge	0.0004	0.0003	0.0000	0.0000
Blue Range Wilderness	0.0002	0.0002	0.0000	0.0000
Bosque Del Apache National Wildlife Refuge	0.0005	0.0004	0.0000	0.0000
Browns Park National Wildlife Refuge	0.0002	0.0001	0.0000	0.0000
Canyon de Chelly NM	0.0007	0.0005	0.0000	0.0000
Capitan Mountains Wilderness	0.0005	0.0005	0.0000	0.0000
Chaco Culture NHP	0.0022	0.0020	0.0000	0.0000
Chama River Canyon Wilderness	0.0181	0.0123	0.0001	0.0001
Chimney Rock NM	0.0360	0.0360	0.0003	0.0003
Colorado NM	0.0012	0.0011	0.0000	0.0000
Cruces Basin Wilderness	0.0137	0.0117	0.0002	0.0002
Curecanti NRA	0.0016	0.0013	0.0000	0.0000
Dark Canyon Wilderness	0.0031	0.0024	0.0000	0.0000
Dinosaur NM	0.0004	0.0003	0.0000	0.0000
Dome Wilderness	0.0033	0.0031	0.0000	0.0000
El Malpais NM	0.0008	0.0005	0.0000	0.0000
Escudilla Wilderness	0.0002	0.0002	0.0000	0.0000
Flaming Gorge	0.0002	0.0001	0.0000	0.0000
Florissant Fossil Beds NM	0.0011	0.0011	0.0000	0.0000
Fossil Ridge Wilderness	0.0019	0.0017	0.0000	0.0000
Glen Canyon NRA	0.0057	0.0010	0.0000	0.0000
Great Sand Dunes National Park	0.0044	0.0035	0.0000	0.0000
Great Sand Dunes National Preserve	0.0047	0.0041	0.0001	0.0000
Greenhorn Mountain Wilderness	0.0034	0.0030	0.0000	0.0000
High Uintas Wilderness	0.0001	0.0001	0.0000	0.0000
Holy Cross Wilderness	0.0011	0.0009	0.0000	0.0000
Hovenweep NM	0.0065	0.0062	0.0000	0.0000
Hunter-Fryingpan Wilderness	0.0013	0.0010	0.0000	0.0000

Class II Area	New Mexico Farmington Field Office			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Las Vegas National Wildlife Refuge	0.0018	0.0015	0.0000	0.0000
Latir Peak Wilderness	0.0048	0.0042	0.0000	0.0000
Lizard Head Wilderness	0.0048	0.0042	0.0001	0.0001
Lost Creek Wilderness	0.0012	0.0011	0.0000	0.0000
Manzano Mountain Wilderness	0.0034	0.0028	0.0000	0.0000
Maxwell National Wildlife Refuge	0.0016	0.0014	0.0000	0.0000
Monte Vista National Wildlife Refuge	0.0049	0.0040	0.0000	0.0000
Mount Evans Wilderness	0.0010	0.0009	0.0000	0.0000
Mount Sneffels Wilderness	0.0037	0.0033	0.0001	0.0001
Natural Bridges NM	0.0031	0.0028	0.0000	0.0000
Navajo NM	0.0005	0.0005	0.0000	0.0000
Petroglyph NM	0.0018	0.0017	0.0000	0.0000
Powderhorn Wilderness	0.0033	0.0028	0.0001	0.0000
Raggeds Wilderness	0.0014	0.0012	0.0000	0.0000
Rio Mora National Wildlife Refuge and Conservation Area	0.0021	0.0018	0.0000	0.0000
Sandia Mountain Wilderness	0.0031	0.0022	0.0000	0.0000
Sangre de Cristo Wilderness	0.0055	0.0036	0.0001	0.0000
Savage Run Wilderness	0.0003	0.0003	0.0000	0.0000
Sevilleta National Wildlife Refuge	0.0011	0.0008	0.0000	0.0000
South San Juan Wilderness	0.0240	0.0170	0.0004	0.0003
Spanish Peaks Wilderness	0.0042	0.0039	0.0001	0.0001
Uncompahgre Wilderness	0.0037	0.0026	0.0001	0.0000
Valle De Oro National Wildlife Refuge	0.0010	0.0010	0.0000	0.0000
Withington Wilderness	0.0003	0.0003	0.0000	0.0000

Table 6-5. FFO sulfur and nitrogen deposition Impacts at Class I areas for Medium Development Scenario.

Class I Area	New Mexico Farmington Field Office			
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Arches NP	0.0012	0.0010	0.0000	0.0000
Bandelier Wilderness	0.0042	0.0038	0.0001	0.0000
Black Canyon of the Gunnison Wilderness	0.0020	0.0018	0.0000	0.0000
Bosque del Apache	0.0006	0.0005	0.0000	0.0000
Canyonlands NP	0.0029	0.0011	0.0000	0.0000
Capitol Reef NP	0.0007	0.0003	0.0000	0.0000
Dinosaur NM	0.0004	0.0003	0.0000	0.0000
Eagles Nest Wilderness	0.0012	0.0009	0.0000	0.0000
Flat Tops Wilderness	0.0010	0.0008	0.0000	0.0000
Gila Wilderness	0.0002	0.0001	0.0000	0.0000
Great Sand Dunes Wilderness-nps	0.0048	0.0039	0.0001	0.0000
La Garita Wilderness	0.0051	0.0041	0.0001	0.0001
Maroon Bells-Snowmass Wilderness	0.0018	0.0014	0.0000	0.0000
Mesa Verde NP	0.0195	0.0153	0.0002	0.0001
Mount Baldy Wilderness	0.0002	0.0002	0.0000	0.0000
Mount Zirkel Wilderness	0.0007	0.0006	0.0000	0.0000
Pecos Wilderness	0.0063	0.0046	0.0001	0.0000
Petrified Forest NP	0.0002	0.0002	0.0000	0.0000
Rawah Wilderness	0.0008	0.0006	0.0000	0.0000
Rocky Mountain NP	0.0009	0.0006	0.0000	0.0000
Salt Creek Wilderness	0.0004	0.0004	0.0000	0.0000
San Pedro Parks Wilderness	0.0068	0.0052	0.0001	0.0000
Weminuche Wilderness	0.0186	0.0091	0.0004	0.0002
West Elk Wilderness	0.0019	0.0015	0.0000	0.0000
Wheeler Peak Wilderness	0.0057	0.0047	0.0001	0.0001
White Mountain Wilderness	0.0006	0.0005	0.0000	0.0000

Table 6-6. FFO sulfur and nitrogen deposition Impacts at Class II areas for Medium Development Scenario.

Class II Area	New Mexico Farmington Field Office			
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Alamosa National Wildlife Refuge	0.0049	0.0045	0.0001	0.0001
Aldo Leopold Wilderness	0.0002	0.0002	0.0000	0.0000
Apache Kid Wilderness	0.0003	0.0003	0.0000	0.0000
Aztec Ruins NM	0.0807	0.0786	0.0012	0.0012
Baca National Wildlife Refuge	0.0039	0.0033	0.0000	0.0000
Bear Wallow Wilderness	0.0001	0.0001	0.0000	0.0000
Bitter Lake National Wildlife Refuge	0.0004	0.0004	0.0000	0.0000
Blue Range Wilderness	0.0002	0.0002	0.0000	0.0000
Bosque Del Apache National Wildlife Refuge	0.0006	0.0005	0.0000	0.0000
Browns Park National Wildlife Refuge	0.0002	0.0002	0.0000	0.0000
Canyon de Chelly NM	0.0008	0.0005	0.0000	0.0000
Capitan Mountains Wilderness	0.0006	0.0006	0.0000	0.0000
Chaco Culture NHP	0.0026	0.0022	0.0000	0.0000
Chama River Canyon Wilderness	0.0206	0.0140	0.0002	0.0001
Chimney Rock NM	0.0409	0.0409	0.0004	0.0004
Colorado NM	0.0014	0.0012	0.0000	0.0000
Cruces Basin Wilderness	0.0156	0.0134	0.0003	0.0002
Curecanti NRA	0.0018	0.0014	0.0000	0.0000
Dark Canyon Wilderness	0.0035	0.0028	0.0000	0.0000
Dinosaur NM	0.0005	0.0003	0.0000	0.0000
Dome Wilderness	0.0038	0.0036	0.0000	0.0000
El Malpais NM	0.0009	0.0006	0.0000	0.0000
Escudilla Wilderness	0.0002	0.0002	0.0000	0.0000
Flaming Gorge	0.0003	0.0001	0.0000	0.0000
Florissant Fossil Beds NM	0.0012	0.0012	0.0000	0.0000
Fossil Ridge Wilderness	0.0021	0.0019	0.0000	0.0000
Glen Canyon NRA	0.0065	0.0011	0.0000	0.0000
Great Sand Dunes National Park	0.0050	0.0039	0.0001	0.0000
Great Sand Dunes National Preserve	0.0054	0.0047	0.0001	0.0001
Greenhorn Mountain Wilderness	0.0039	0.0034	0.0001	0.0000
High Uintas Wilderness	0.0002	0.0001	0.0000	0.0000
Holy Cross Wilderness	0.0012	0.0010	0.0000	0.0000
Hovenweep NM	0.0074	0.0071	0.0000	0.0000
Hunter-Fryingpan Wilderness	0.0015	0.0012	0.0000	0.0000

Class II Area	New Mexico Farmington Field Office			
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Las Vegas National Wildlife Refuge	0.0021	0.0017	0.0000	0.0000
Latir Peak Wilderness	0.0054	0.0047	0.0001	0.0001
Lizard Head Wilderness	0.0054	0.0048	0.0001	0.0001
Lost Creek Wilderness	0.0014	0.0012	0.0000	0.0000
Manzano Mountain Wilderness	0.0038	0.0032	0.0000	0.0000
Maxwell National Wildlife Refuge	0.0018	0.0016	0.0000	0.0000
Monte Vista National Wildlife Refuge	0.0056	0.0046	0.0001	0.0001
Mount Evans Wilderness	0.0012	0.0010	0.0000	0.0000
Mount Sneffels Wilderness	0.0042	0.0038	0.0001	0.0001
Natural Bridges NM	0.0035	0.0032	0.0000	0.0000
Navajo NM	0.0005	0.0005	0.0000	0.0000
Petroglyph NM	0.0021	0.0019	0.0000	0.0000
Powderhorn Wilderness	0.0038	0.0032	0.0001	0.0001
Raggeds Wilderness	0.0015	0.0013	0.0000	0.0000
Rio Mora National Wildlife Refuge and Conservation Area	0.0024	0.0021	0.0000	0.0000
Sandia Mountain Wilderness	0.0035	0.0025	0.0000	0.0000
Sangre de Cristo Wilderness	0.0063	0.0041	0.0001	0.0001
Savage Run Wilderness	0.0004	0.0003	0.0000	0.0000
Sevilleta National Wildlife Refuge	0.0013	0.0009	0.0000	0.0000
South San Juan Wilderness	0.0273	0.0193	0.0005	0.0004
Spanish Peaks Wilderness	0.0048	0.0044	0.0001	0.0001
Uncompahgre Wilderness	0.0042	0.0030	0.0001	0.0001
Valle De Oro National Wildlife Refuge	0.0012	0.0012	0.0000	0.0000
Withington Wilderness	0.0004	0.0003	0.0000	0.0000

6.2 Cumulative Deposition

Table 6-7 reports total nitrogen and sulfur deposition at the Class I areas for the 2025 High Development Scenario. Table 6-8 and Table 6-9 report the same information for the 2025 Low and Medium Development Scenarios, respectively. Table 6-10, Table 6-11, and Table 6-12 report the same information for the Class II areas, for 2025 High, Low and Medium Development Scenarios. These values can be compare with Critical Loads that were discussed in Section 6.0.

Table 6-7. 2025 Total Deposition: High Scenario at Class I Areas.

Class I Area	2025 Total			
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Arches NP	1.4707	1.3396	0.2345	0.2003
Bandelier Wilderness	7.0526	2.9486	1.0210	0.4449
Black Canyon of the Gunnison Wilderness	2.4137	1.9468	0.3206	0.2848
Bosque del Apache	1.6093	1.3927	0.4326	0.3383
Canyonlands NP	1.4534	1.1933	0.3246	0.1979
Capitol Reef NP	2.1542	1.2894	0.3160	0.2071
Dinosaur NM	2.6162	1.8164	0.4209	0.3139
Eagles Nest Wilderness	2.2708	1.8496	0.8305	0.5547
Flat Tops Wilderness	2.3209	1.9607	0.8434	0.6501
Gila Wilderness	2.7461	1.9479	1.3161	0.7020
Great Sand Dunes Wilderness-nps	1.9011	1.5270	0.4241	0.3229
La Garita Wilderness	1.5820	1.2759	0.6165	0.4708
Maroon Bells-Snowmass Wilderness	2.1762	1.7599	0.9006	0.6671
Mesa Verde NP	2.2714	2.0241	0.4812	0.4112
Mount Baldy Wilderness	1.9079	1.9079	0.7259	0.7259
Mount Zirkel Wilderness	3.1053	2.4635	1.2684	0.9162
Pecos Wilderness	4.0067	1.9903	0.8080	0.5308
Petrified Forest NP	2.1944	1.7117	0.3302	0.2791
Rawah Wilderness	2.5901	2.1470	0.9076	0.6674
Rocky Mountain NP	2.4848	2.0216	0.8493	0.6302
Salt Creek Wilderness	2.4210	2.3604	0.4762	0.4469
San Pedro Parks Wilderness	2.0221	1.8944	0.6368	0.5347
Weminuche Wilderness	2.1008	1.6242	0.9580	0.6711
West Elk Wilderness	1.9710	1.5706	0.7511	0.5250
Wheeler Peak Wilderness	2.1621	1.9412	0.8166	0.6862
White Mountain Wilderness	1.8789	1.7175	0.5388	0.3977

Table 6-8. 2025 Total Deposition: Low Scenario at Class I Areas.

Class I Area	2025 Total			
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Arches NP	1.3646	1.2578	0.2329	0.1987
Bandelier Wilderness	7.0361	2.9315	1.0207	0.4446
Black Canyon of the Gunnison Wilderness	2.2918	1.8526	0.3186	0.2822
Bosque del Apache	1.6048	1.3888	0.4326	0.3382
Canyonlands NP	1.4289	1.1632	0.3241	0.1972
Capitol Reef NP	2.1497	1.2829	0.3159	0.2070
Dinosaur NM	2.5708	1.7595	0.4187	0.3100
Eagles Nest Wilderness	2.1010	1.7179	0.8232	0.5488
Flat Tops Wilderness	2.0892	1.7525	0.8288	0.6351
Gila Wilderness	2.7450	1.9465	1.3161	0.7020
Great Sand Dunes Wilderness-nps	1.8696	1.4918	0.4232	0.3221
La Garita Wilderness	1.5356	1.2418	0.6147	0.4697
Maroon Bells-Snowmass Wilderness	2.0513	1.6502	0.8952	0.6628
Mesa Verde NP	2.2004	1.9632	0.4799	0.4102
Mount Baldy Wilderness	1.9056	1.9056	0.7258	0.7258
Mount Zirkel Wilderness	2.8813	2.2887	1.2534	0.9041
Pecos Wilderness	3.9852	1.9694	0.8075	0.5305
Petrified Forest NP	2.1906	1.7078	0.3301	0.2790
Rawah Wilderness	2.4246	2.0103	0.8981	0.6592
Rocky Mountain NP	2.3280	1.9027	0.8415	0.6241
Salt Creek Wilderness	2.4161	2.3554	0.4761	0.4469
San Pedro Parks Wilderness	2.0013	1.8733	0.6364	0.5343
Weminuche Wilderness	2.0345	1.5836	0.9568	0.6701
West Elk Wilderness	1.8832	1.4946	0.7476	0.5222
Wheeler Peak Wilderness	2.1319	1.9144	0.8160	0.6857
White Mountain Wilderness	1.8743	1.7129	0.5387	0.3977

Table 6-9. 2025 Total Deposition: Medium Scenario at Class I Areas.

Class I Area	2025 Total			
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Arches NP	1.4574	1.3290	0.2344	0.2002
Bandelier Wilderness	7.0459	2.9417	1.0210	0.4449
Black Canyon of the Gunnison Wilderness	2.3975	1.9341	0.3206	0.2847
Bosque del Apache	1.6081	1.3917	0.4326	0.3383
Canyonlands NP	1.4466	1.1881	0.3246	0.1979
Capitol Reef NP	2.1534	1.2881	0.3160	0.2071
Dinosaur NM	2.6103	1.8091	0.4209	0.3139
Eagles Nest Wilderness	2.2513	1.8345	0.8303	0.5546
Flat Tops Wilderness	2.2873	1.9368	0.8433	0.6500
Gila Wilderness	2.7459	1.9475	1.3161	0.7020
Great Sand Dunes Wilderness-nps	1.8915	1.5167	0.4240	0.3228
La Garita Wilderness	1.5692	1.2650	0.6163	0.4707
Maroon Bells-Snowmass Wilderness	2.1608	1.7465	0.9005	0.6670
Mesa Verde NP	2.2305	1.9880	0.4810	0.4110
Mount Baldy Wilderness	1.9074	1.9074	0.7259	0.7259
Mount Zirkel Wilderness	3.0786	2.4426	1.2684	0.9162
Pecos Wilderness	3.9968	1.9813	0.8079	0.5307
Petrified Forest NP	2.1937	1.7110	0.3302	0.2791
Rawah Wilderness	2.5699	2.1303	0.9075	0.6673
Rocky Mountain NP	2.4678	2.0091	0.8492	0.6301
Salt Creek Wilderness	2.4200	2.3593	0.4762	0.4469
San Pedro Parks Wilderness	2.0135	1.8855	0.6367	0.5347
Weminuche Wilderness	2.0591	1.6024	0.9577	0.6709
West Elk Wilderness	1.9589	1.5604	0.7510	0.5249
Wheeler Peak Wilderness	2.1508	1.9315	0.8165	0.6862
White Mountain Wilderness	1.8777	1.7163	0.5388	0.3977

Table 6-10. 2025 Total Deposition: High Scenario at Class II Areas.

Class II Area	2025 Total			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Alamosa National Wildlife Refuge	1.7089	1.5269	0.3320	0.3036
Aldo Leopold Wilderness	2.4100	1.7663	1.2150	0.6125
Apache Kid Wilderness	1.5464	1.3838	0.5415	0.4129
Aztec Ruins NM	3.6796	3.6167	0.5004	0.4604
Baca National Wildlife Refuge	5.4321	1.4201	0.2470	0.2141
Bear Wallow Wilderness	3.4518	3.4518	0.8781	0.8781
Bitter Lake National Wildlife Refuge	2.4253	2.2551	0.4762	0.4211
Blue Range Wilderness	2.7774	2.3338	0.8289	0.7716
Bosque Del Apache National Wildlife Refuge	1.6093	1.3927	0.4326	0.3383
Browns Park National Wildlife Refuge	1.8043	1.4577	0.2632	0.2092
Canyon de Chelly NM	2.2300	1.3434	0.4224	0.2949
Capitan Mountains Wilderness	2.7110	2.3117	0.6931	0.4722
Chaco Culture NHP	3.2284	1.5106	0.3921	0.2821
Chama River Canyon Wilderness	2.2063	1.8721	0.4136	0.3483
Chimney Rock NM	2.0070	2.0070	0.2970	0.2970
Colorado NM	2.2594	1.8499	0.3255	0.2800
Cruces Basin Wilderness	2.0753	1.7757	0.7385	0.6222
Curecanti NRA	1.5873	1.2398	0.3635	0.2789
Dark Canyon Wilderness	1.7298	1.5633	0.4735	0.3818
Dinosaur NM	2.7915	1.8910	0.4209	0.2990
Dome Wilderness	3.4851	3.0375	0.4983	0.4589
El Malpais NM	1.9295	1.5673	0.4703	0.3578
Escudilla Wilderness	3.6592	3.6592	0.9981	0.9981
Flaming Gorge	2.1847	1.4678	0.5670	0.3287
Florissant Fossil Beds NM	2.0221	1.9479	0.3743	0.3539
Fossil Ridge Wilderness	1.7268	1.5281	0.5955	0.4618
Glen Canyon NRA	2.0622	1.2266	0.5549	0.2088
Great Sand Dunes National Park	3.8392	1.5875	0.4241	0.3066
Great Sand Dunes National Preserve	2.0863	1.8863	0.6980	0.5124
Greenhorn Mountain Wilderness	2.1615	1.9822	0.6050	0.4892
High Uintas Wilderness	1.8813	1.6166	0.7594	0.5759
Holy Cross Wilderness	2.0649	1.7310	0.7511	0.5627
Hovenweep NM	1.5112	1.4144	0.2691	0.2580
Hunter-Fryingpan Wilderness	2.0197	1.6520	0.8038	0.5751
Las Vegas National Wildlife Refuge	2.7316	2.0411	0.3819	0.3256

Class II Area	2025 Total			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Latir Peak Wilderness	1.9568	1.7195	0.6451	0.4722
Lizard Head Wilderness	2.1222	1.8279	0.9914	0.8031
Lost Creek Wilderness	2.2579	2.0096	0.6529	0.5312
Manzano Mountain Wilderness	4.8088	4.1048	0.9896	0.7728
Maxwell National Wildlife Refuge	1.3254	1.2228	0.3344	0.3270
Monte Vista National Wildlife Refuge	1.7027	1.3470	0.2774	0.2352
Mount Evans Wilderness	2.3480	1.9593	0.8136	0.6207
Mount Sneffels Wilderness	2.1489	1.9009	1.0421	0.8279
Natural Bridges NM	1.3686	1.3442	0.2753	0.2672
Navajo NM	1.2611	1.2611	0.2406	0.2406
Petroglyph NM	3.7103	2.3813	0.2838	0.2650
Powderhorn Wilderness	1.6256	1.3051	0.6183	0.4356
Raggeds Wilderness	1.9941	1.6986	0.8704	0.6043
Rio Mora National Wildlife Refuge and Conservation Area	1.8258	1.6365	0.3419	0.3233
Sandia Mountain Wilderness	4.4567	2.8582	0.5315	0.4343
Sangre de Cristo Wilderness	2.4266	1.8615	0.9611	0.5233
Savage Run Wilderness	2.3146	2.0161	0.7030	0.5180
Sevilleta National Wildlife Refuge	3.9195	2.0158	0.3987	0.3205
South San Juan Wilderness	2.1968	1.9442	0.8765	0.7124
Spanish Peaks Wilderness	2.5412	2.3513	0.8968	0.7875
Uncompahgre Wilderness	1.9665	1.5887	0.8554	0.6562
Valle De Oro National Wildlife Refuge	5.7340	5.7340	0.2130	0.2130
Withington Wilderness	1.6900	1.3676	0.6645	0.4661

Table 6-11. 2025 Total Deposition: Low Scenario at Class II Areas.

Class II Area	2025 Total			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Alamosa National Wildlife Refuge	1.6835	1.5013	0.3315	0.3031
Aldo Leopold Wilderness	2.4083	1.7646	1.2150	0.6125
Apache Kid Wilderness	1.5434	1.3811	0.5414	0.4128
Aztec Ruins NM	3.5358	3.4815	0.4982	0.4584
Baca National Wildlife Refuge	5.4111	1.3907	0.2465	0.2136
Bear Wallow Wilderness	3.4499	3.4499	0.8780	0.8780
Bitter Lake National Wildlife Refuge	2.4215	2.2507	0.4761	0.4210
Blue Range Wilderness	2.7749	2.3314	0.8288	0.7715
Bosque Del Apache National Wildlife Refuge	1.6048	1.3888	0.4326	0.3382
Browns Park National Wildlife Refuge	1.7801	1.4333	0.2621	0.2081
Canyon de Chelly NM	2.2199	1.3345	0.4222	0.2947
Capitan Mountains Wilderness	2.7055	2.3058	0.6930	0.4721
Chaco Culture NHP	3.2162	1.4973	0.3919	0.2818
Chama River Canyon Wilderness	2.1534	1.8343	0.4131	0.3478
Chimney Rock NM	1.8880	1.8880	0.2958	0.2958
Colorado NM	2.1135	1.7276	0.3219	0.2769
Cruces Basin Wilderness	2.0284	1.7354	0.7376	0.6215
Curecanti NRA	1.5138	1.1856	0.3615	0.2774
Dark Canyon Wilderness	1.7044	1.5380	0.4729	0.3810
Dinosaur NM	2.7579	1.8284	0.4187	0.2943
Dome Wilderness	3.4687	3.0204	0.4980	0.4587
El Malpais NM	1.9200	1.5609	0.4700	0.3576
Escudilla Wilderness	3.6562	3.6562	0.9980	0.9980
Flaming Gorge	2.1731	1.4596	0.5666	0.3284
Florissant Fossil Beds NM	1.9657	1.8934	0.3730	0.3527
Fossil Ridge Wilderness	1.6601	1.4673	0.5932	0.4599
Glen Canyon NRA	2.0458	1.2119	0.5547	0.2085
Great Sand Dunes National Park	3.8090	1.5539	0.4232	0.3059
Great Sand Dunes National Preserve	2.0422	1.8418	0.6968	0.5114
Greenhorn Mountain Wilderness	2.1127	1.9372	0.6040	0.4883
High Uintas Wilderness	1.8786	1.6128	0.7590	0.5757
Holy Cross Wilderness	1.9193	1.6094	0.7441	0.5571
Hovenweep NM	1.4721	1.3783	0.2674	0.2565
Hunter-Fryingpan Wilderness	1.8995	1.5479	0.7979	0.5701
Las Vegas National Wildlife Refuge	2.7179	2.0290	0.3816	0.3253

Class II Area	2025 Total			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Latir Peak Wilderness	1.9235	1.6898	0.6444	0.4717
Lizard Head Wilderness	2.0761	1.7858	0.9900	0.8018
Lost Creek Wilderness	2.1568	1.9195	0.6498	0.5285
Manzano Mountain Wilderness	4.7812	4.0825	0.9891	0.7725
Maxwell National Wildlife Refuge	1.3040	1.2038	0.3340	0.3266
Monte Vista National Wildlife Refuge	1.6724	1.3241	0.2768	0.2347
Mount Evans Wilderness	2.2320	1.8596	0.8094	0.6171
Mount Sneffels Wilderness	2.1002	1.8508	1.0398	0.8260
Natural Bridges NM	1.3485	1.3245	0.2748	0.2668
Navajo NM	1.2522	1.2522	0.2403	0.2403
Petroglyph NM	3.6992	2.3698	0.2836	0.2648
Powderhorn Wilderness	1.5756	1.2656	0.6165	0.4343
Raggeds Wilderness	1.8643	1.5778	0.8659	0.6003
Rio Mora National Wildlife Refuge and Conservation Area	1.8078	1.6215	0.3416	0.3231
Sandia Mountain Wilderness	4.4401	2.8417	0.5312	0.4341
Sangre de Cristo Wilderness	2.3747	1.8167	0.9595	0.5223
Savage Run Wilderness	2.2188	1.9353	0.6962	0.5129
Sevilleta National Wildlife Refuge	3.9136	2.0093	0.3986	0.3203
South San Juan Wilderness	2.1192	1.8838	0.8753	0.7113
Spanish Peaks Wilderness	2.4838	2.2984	0.8950	0.7859
Uncompahgre Wilderness	1.9159	1.5456	0.8536	0.6544
Valle De Oro National Wildlife Refuge	5.7279	5.7279	0.2129	0.2129
Withington Wilderness	1.6863	1.3643	0.6644	0.4660

Table 6-12. 2025 Total Deposition: Medium Scenario at Class II Areas.

Class II Area	2025 Total			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Alamosa National Wildlife Refuge	1.6992	1.5176	0.3319	0.3035
Aldo Leopold Wilderness	2.4096	1.7659	1.2150	0.6125
Apache Kid Wilderness	1.5457	1.3831	0.5415	0.4129
Aztec Ruins NM	3.5736	3.5186	0.4993	0.4595
Baca National Wildlife Refuge	5.4256	1.4110	0.2470	0.2141
Bear Wallow Wilderness	3.4514	3.4514	0.8781	0.8781
Bitter Lake National Wildlife Refuge	2.4245	2.2542	0.4762	0.4211
Blue Range Wilderness	2.7768	2.3332	0.8289	0.7716
Bosque Del Apache National Wildlife Refuge	1.6081	1.3917	0.4326	0.3383
Browns Park National Wildlife Refuge	1.8014	1.4549	0.2632	0.2092
Canyon de Chelly NM	2.2278	1.3417	0.4224	0.2949
Capitan Mountains Wilderness	2.7098	2.3104	0.6931	0.4722
Chaco Culture NHP	3.2246	1.5061	0.3921	0.2820
Chama River Canyon Wilderness	2.1763	1.8518	0.4135	0.3482
Chimney Rock NM	1.9127	1.9127	0.2964	0.2964
Colorado NM	2.2415	1.8346	0.3254	0.2799
Cruces Basin Wilderness	2.0477	1.7522	0.7383	0.6220
Curecanti NRA	1.5771	1.2318	0.3634	0.2789
Dark Canyon Wilderness	1.7211	1.5560	0.4735	0.3818
Dinosaur NM	2.7869	1.8829	0.4209	0.2990
Dome Wilderness	3.4788	3.0309	0.4982	0.4589
El Malpais NM	1.9270	1.5658	0.4703	0.3578
Escudilla Wilderness	3.6585	3.6585	0.9981	0.9981
Flaming Gorge	2.1830	1.4666	0.5670	0.3287
Florissant Fossil Beds NM	2.0158	1.9418	0.3743	0.3539
Fossil Ridge Wilderness	1.7166	1.5189	0.5954	0.4617
Glen Canyon NRA	2.0585	1.2232	0.5549	0.2088
Great Sand Dunes National Park	3.8296	1.5774	0.4240	0.3065
Great Sand Dunes National Preserve	2.0738	1.8735	0.6979	0.5123
Greenhorn Mountain Wilderness	2.1526	1.9725	0.6049	0.4891
High Uintas Wilderness	1.8808	1.6160	0.7594	0.5759
Holy Cross Wilderness	2.0479	1.7168	0.7510	0.5626
Hovenweep NM	1.4947	1.3987	0.2690	0.2579
Hunter-Fryingpan Wilderness	2.0051	1.6395	0.8036	0.5750
Las Vegas National Wildlife Refuge	2.7277	2.0377	0.3819	0.3255

Class II Area	2025 Total			
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Latir Peak Wilderness	1.9454	1.7094	0.6450	0.4722
Lizard Head Wilderness	2.1082	1.8150	0.9912	0.8030
Lost Creek Wilderness	2.2478	2.0000	0.6529	0.5311
Manzano Mountain Wilderness	4.8004	4.0979	0.9895	0.7728
Maxwell National Wildlife Refuge	1.3211	1.2190	0.3344	0.3270
Monte Vista National Wildlife Refuge	1.6907	1.3375	0.2773	0.2352
Mount Evans Wilderness	2.3364	1.9490	0.8135	0.6207
Mount Sneffels Wilderness	2.1365	1.8896	1.0420	0.8278
Natural Bridges NM	1.3605	1.3367	0.2753	0.2672
Navajo NM	1.2593	1.2593	0.2406	0.2406
Petroglyph NM	3.7065	2.3774	0.2838	0.2650
Powderhorn Wilderness	1.6143	1.2954	0.6182	0.4355
Raggeds Wilderness	1.9807	1.6854	0.8703	0.6042
Rio Mora National Wildlife Refuge and Conservation Area	1.8206	1.6321	0.3419	0.3233
Sandia Mountain Wilderness	4.4513	2.8530	0.5315	0.4343
Sangre de Cristo Wilderness	2.4121	1.8500	0.9610	0.5232
Savage Run Wilderness	2.3030	2.0062	0.7030	0.5180
Sevilleta National Wildlife Refuge	3.9177	2.0139	0.3987	0.3205
South San Juan Wilderness	2.1450	1.9057	0.8761	0.7121
Spanish Peaks Wilderness	2.5296	2.3407	0.8967	0.7874
Uncompahgre Wilderness	1.9551	1.5789	0.8553	0.6561
Valle De Oro National Wildlife Refuge	5.7320	5.7320	0.2130	0.2130
Withington Wilderness	1.6891	1.3668	0.6645	0.4661

7.0 ACID NEUTRALIZING CAPACITY AT SENSITIVE LAKES

In addition to calculation of total deposition fluxes, an additional analysis was performed to assess the change in water chemistry associated with atmospheric deposition from FFO emissions and cumulative sources for each of the sensitive lakes in the 12/4 km CARMMS 2.0 modeling domain. These lakes are listed in Table 7-1 and are also shown in Figure 4-1. This analysis assesses the change in the acid neutralizing capacity (ANC) of sensitive lakes. An estimate of potential changes in ANC was made by following the procedure developed by the USFS Rocky Mountain Region (USFS, 2000). Predicted changes in ANC are compared with the threshold (10 percent change in ANC for lakes with background ANC values greater than 25 micro equivalents per liter [μeq/L], and no more than a 1 μeq/L change in ANC for lakes with background ANC values equal to or less than 25 μeq/L). The list of sensitive lakes was obtained from the USFS. The most recent lake chemistry background ANC data was obtained from the VIEWS website for each of the sensitive lakes and is shown in Table 7-2.

Table 7-1. List of sensitive lakes for ANC analysis.

Lake	National Forest	Wilderness Area
Brooklyn Lake	White River	Collegiate Peaks
Tabor Lake	White River	Collegiate Peaks
Booth Lake	White River	Eagles Nest
Upper Willow Lake	White River	Eagles Nest
Ned Wilson Lake	White River	Flat Tops
Upper Ned Wilson Lake	White River	Flat Tops
Lower NWL Packtrail Pothole	White River	Flat Tops
Upper NWL Packtrail Pothole	White River	Flat Tops
Walk Up Lake	Ashley	--
Bluebell Lake	Ashley	High Uintas
Dean Lake	Ashley	High Uintas
No Name (Utah, Duchesne – 4D2-039)	Ashley	High Uintas
Upper Coffin Lake	Ashley	High Uintas
Fish Lake	Wasatch-Cache	High Uintas
Blodgett Lake, Colorado	White River	Holy Cross
Upper Turquoise Lake	White River	Holy Cross
Upper West Tennessee Lake	San Isabel	Holy Cross
Blue Lake (Colorado; Boulder – 4E1-040)	Arapaho and Roosevelt	Indian Peaks
Crater Lake	Arapaho and Roosevelt	Indian Peaks
King Lake (Colorado; Grand – 4E1-049)	Arapaho and Roosevelt	Indian Peaks
No Name Lake (Colorado; Boulder – 4E1-055)	Arapaho and Roosevelt	Indian Peaks
Upper Lake	Arapaho and Roosevelt	Indian Peaks
Small Lake Above U-Shaped Lake	Rio Grande	La Garita

Lake	National Forest	Wilderness Area
U-Shaped Lake	Rio Grande	La Garita
Avalanche Lake	White River	Maroon Bells
Capitol Lake	White River	Maroon Bells
Moon Lake (Upper)	White River	Maroon Bells
Upper Middle Beartrack Lake	Arapaho and Roosevelt	Mount Evans
Abyss Lake	Pike and San Isabel	Mount Evans
Frozen Lake	Pike and San Isabel	Mount Evans
North Lake	Pike and San Isabel	Mount Evans
South Lake	Pike and San Isabel	Mount Evans
Lake Elbert	Medicine Bow-Routt	Mount Zirkel
Seven Lakes (LG East)	Medicine Bow-Routt	Mount Zirkel
Summit Lake	Medicine Bow-Routt	Mount Zirkel
Deep Creek Lake	Gunnison	Raggeds
Island Lake	Arapaho and Roosevelt	Rawah
Kelly Lake	Arapaho and Roosevelt	Rawah
Rawah Lake #4	Arapaho and Roosevelt	Rawah
Crater Lake (Sangre de Cristo)	Rio Grande	Sangre de Cristo
Lower Stout Lake	San Isabel	Sangre de Cristo
Upper Little Sand Creek Lake	San Isabel	Sangre de Cristo
Upper Stout Lake	San Isabel	Sangre de Cristo
Glacier Lake (Colorado)	San Juan-Rio Grande	South San Juan
Lake South of Blue Lakes	San Juan-Rio Grande	South San Juan
Big Eldorado Lake	San Juan-Rio Grande	Weminuche
Four Mile Pothole	San Juan-Rio Grande	Weminuche
Lake Due South of Ute Lake	San Juan-Rio Grande	Weminuche
Little Eldorado	San Juan-Rio Grande	Weminuche
Little Granite Lake	San Juan-Rio Grande	Weminuche
Lower Sunlight Lake	San Juan-Rio Grande	Weminuche
Middle Ute Lake	San Juan-Rio Grande	Weminuche
Small Pond Above Trout Lake	San Juan-Rio Grande	Weminuche
Upper Grizzly Lake	San Juan-Rio Grande	Weminuche
Upper Sunlight Lake	San Juan-Rio Grande	Weminuche
West Snowdon Lake	San Juan-Rio Grande	Weminuche
White Dome Lake	San Juan-Rio Grande	Weminuche
South Golden Lake	Grand Mesa, Uncompahgre and Gunnison	West Elk

Table 7-2. Lake chemistry monitored background data for ANC analysis.

Lake	State	Latitude (Deg N)	Longitude (Deg W)	10th Percentile Lowest ANC Value (µeq/L)	Number of Samples	Period of Monitoring
Brooklyn Lake	CO	39.0495	-106.6569	101.7	59	1991-2010
Tabor Lake	CO	39.0628	-106.6564	112.4	63	1991-2010
Booth Lake	CO	39.6986	-106.3050	86.8	49	1993-2010
Upper Willow Lake	CO	39.6458	-106.1747	134.1	52	1990-2011
Ned Wilson Lake	CO	39.9614	-107.3239	39.0	191	1981-2007
Upper Ned Wilson Lake	CO	39.9628	-107.3236	12.9	143	1983-2007
Lower NWL Packtrail Pothole	CO	39.9682	-107.3241	29.7	96	1987-2007
Upper NWL Packtrail Pothole	CO	39.9656	-107.3238	48.7	96	1987-2007
Walk Up Lake	UT	40.8110	-110.0383	55.2	10	2002-2011
Bluebell Lake	UT	40.6970	-110.4822	55.5	2	1985-2002
Dean Lake	UT	40.6785	-110.7616	48.9	9	2001-2010
No Name (Utah, Duchesne - 4D2-039)	UT	40.6710	-110.2758	67.0	7	2006-2011
Upper Coffin Lake	UT	40.8342	-110.2383	64.9	6	2006-2011
Fish Lake	UT	40.8361	-110.0676	105.8	9	2001-2011
Blodgett Lake, Colorado	CO	39.4062	-106.5352	47.7	47	1994-2010
Upper Turquoise Lake	CO	39.5098	-106.5332	104.0	45	1994-2010
Upper West Tennessee Lake	CO	39.3445	-106.4250	114.2	47	1995-2010
Blue Lake (Colorado; Boulder - 4E1-040)	CO	40.0876	-105.6169	19.3	35	1995-2010
Crater Lake	CO	40.0755	-105.6639	53.1	29	1996-2010
King Lake (Colorado; Grand - 4E1-049)	CO	39.9441	-105.6858	52.3	29	1985-2010
No Name Lake (Colorado; Boulder - 4E1-055)	CO	40.0375	-105.6269	25.6	27	1996-2010
Upper Lake	CO	40.1545	-105.6805	69.0	30	1995-2010
Small Lake Above U-Shaped Lake	CO	37.9436	-106.8639	59.9	24	1992-2009
U-Shaped Lake	CO	37.9422	-106.8606	81.4	23	1992-2009
Avalanche Lake	CO	39.1439	-107.0998	158.8	55	1991-2010
Capitol Lake	CO	39.1630	-107.0820	154.4	57	1991-2010
Moon Lake (Upper)	CO	39.1644	-107.0589	53.0	54	1991-2010
Upper Middle Beartrack Lake	CO	39.5711	-105.6067	50.9	44	1993-2010
Abyss Lake	CO	39.5858	-105.6592	81.1	49	1993-2010
Frozen Lake	CO	39.5775	-105.6583	93.3	48	1993-2010
North Lake	CO	39.5914	-105.6733	80.9	15	1993-1998
South Lake	CO	39.5903	-105.6714	66.7	15	1993-1998
Lake Elbert	CO	40.6342	-106.7069	56.6	67	1985-2007
Seven Lakes (LG East)	CO	40.8958	-106.6819	36.2	67	1985-2007
Summit Lake	CO	40.5453	-106.6819	48.0	107	1985-2007

Lake	State	Latitude (Deg N)	Longitude (Deg W)	10th Percentile Lowest ANC Value (μeq/L)	Number of Samples	Period of Monitoring
Deep Creek Lake	CO	39.0089	-107.2400	20.6	24	1995-2009
Island Lake	CO	40.6272	-105.9411	71.0	30	1995-2010
Kelly Lake	CO	40.6256	-105.9594	179.9	30	1995-2010
Rawah Lake #4	CO	40.6711	-105.9578	41.3	30	1995-2010
Crater Lake (Sangre de Cristo)	CO	37.5756	-105.4951	162.9	27	1995-2009
Lower Stout Lake	CO	38.3528	-105.8892	145.2	44	1996-2010
Upper Little Sand Creek Lake	CO	37.9039	-105.5356	129.5	36	1995-2010
Upper Stout Lake	CO	38.3503	-105.8908	76.3	44	1996-2010
Glacier Lake (Colorado)	CO	37.2594	-106.5879	63.4	31	1993-2009
Lake South of Blue Lakes	CO	37.2243	-106.6307	16.9	41	1992-2009
Big Eldorado Lake	CO	37.7133	-107.5433	19.6	55	1985-2007
Four Mile Pothole	CO	37.4684	-107.0525	123.4	19	2000-2009
Lake Due South of Ute Lake	CO	37.6361	-107.4428	13.2	24	1992-2009
Little Eldorado	CO	37.7133	-107.5458	-3.3	54	1985-2007
Little Granite Lake	CO	37.6205	-107.3317	80.7	20	2000-2009
Lower Sunlight Lake	CO	37.6331	-107.5830	80.9	52	1985-2007
Middle Ute Lake	CO	37.6483	-107.4752	42.8	29	1985-2009
Small Pond Above Trout Lake	CO	37.6519	-107.1564	25.5	27	1992-2009
Upper Grizzly Lake	CO	37.6200	-107.5836	29.9	45	1985-2007
Upper Sunlight Lake	CO	37.6278	-107.5797	28.0	51	1985-2007
West Snowdon Lake	CO	37.7103	-107.6935	39.4	26	2000-2009
White Dome Lake	CO	37.7089	-107.5525	2.1	52	1985-2007
South Golden Lake	CO	38.7776	-107.1828	111.4	25	1995-2008

7.1 Changes in ANC at Sensitive Lakes due to Emissions from FFO

Table 7-3 reports changes in ANC at sensitive lakes caused by FFO emissions for the 2025 High Development Scenario. The most impacted lake is Lake South of Blues Lake in Colorado, with a predicted change in ANC of 0.3339 μeq/L which is well below the 1.0 μeq/L USFS LAC threshold.

The Low and Medium Development Scenario changes in ANC impacts are presented in Table 7-4 and Table 7-5, respectively. As in the High Scenario, the most impacted lake is Lake South of Blues Lake for the other two Development Scenarios, with changes in ANC well below the USFS LAC thresholds.

Table 7-3. Changes in ANC at sensitive lakes due to FFO emissions for the 2025 High Development Scenario.

Lake	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2025 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	0.0000	0.0028	1.162	0.03%	0.0260	<10%	yes	101.7
Tabor Lake	0.0000	0.0024	1.182	0.02%	0.0223	<10%	yes	112.4
Booth Lake	0.0000	0.0016	1.223	0.02%	0.0145	<10%	yes	86.8
Upper Willow Lake	0.0000	0.0016	1.143	0.01%	0.0155	<10%	yes	134.1
Ned Wilson Lake	0.0000	0.0014	1.180	0.03%	0.0130	<10%	yes	39.0
Upper Ned Wilson Lake	0.0000	0.0014	1.180	0.10%	0.0130	<1(μeq/L)	yes	12.9
Lower NWL Packtrail Pothole	0.0000	0.0014	1.180	0.04%	0.0130	<10%	yes	29.6
Upper NWL Packtrail Pothole	0.0000	0.0014	1.180	0.03%	0.0130	<10%	yes	48.7
Walk Up Lake	0.0000	0.0003	1.011	0.01%	0.0028	<10%	yes	55.2
Bluebell Lake	0.0000	0.0002	0.943	0.00%	0.0023	<10%	yes	55.5
Dean Lake	0.0000	0.0002	1.024	0.00%	0.0019	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	0.0000	0.0003	0.845	0.01%	0.0037	<10%	yes	67.0
Upper Coffin Lake	0.0000	0.0002	1.047	0.00%	0.0025	<10%	yes	64.8
Fish Lake	0.0000	0.0003	1.062	0.00%	0.0027	<10%	yes	105.8
Blodgett Lake, Colorado	0.0000	0.0019	1.159	0.04%	0.0181	<10%	yes	47.6
Upper Turquoise Lake	0.0000	0.0020	1.121	0.02%	0.0196	<10%	yes	104.0
Upper West Tennessee Lake	0.0000	0.0021	1.161	0.02%	0.0199	<10%	yes	114.2
Blue Lake (Colorado; Boulder - 4E1-040)	0.0000	0.0014	1.348	0.06%	0.0112	<1(μeq/L)	yes	19.2
Crater Lake	0.0000	0.0012	1.241	0.02%	0.0104	<10%	yes	53.1
King Lake (Colorado; Grand - 4E1-049)	0.0000	0.0014	1.237	0.02%	0.0124	<10%	yes	52.2

Lake	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (µeq/L)*	USFS LAC Threshold	Below Threshold?	2025 Hi Predicted 10th Percentile Lowest ANC Value (µeq/L)
No Name Lake (Colorado; Boulder - 4E1-055)	0.0000	0.0016	1.449	0.05%	0.0118	<10%	yes	25.6
Upper Lake	0.0000	0.0013	1.225	0.02%	0.0114	<10%	yes	69.0
Small Lake Above U-Shaped Lake	0.0001	0.0080	0.816	0.18%	0.1055	<10%	yes	59.8
U-Shaped Lake	0.0001	0.0080	0.816	0.13%	0.1055	<10%	yes	81.3
Avalanche Lake	0.0000	0.0030	1.337	0.02%	0.0239	<10%	yes	158.8
Capitol Lake	0.0001	0.0031	1.434	0.02%	0.0234	<10%	yes	154.4
Moon Lake (Upper)	0.0001	0.0031	1.434	0.04%	0.0234	<10%	yes	53.0
Upper Middle Beartrack Lake	0.0000	0.0020	1.018	0.04%	0.0212	<10%	yes	50.9
Abyss Lake	0.0000	0.0020	1.118	0.02%	0.0192	<10%	yes	81.1
Frozen Lake	0.0000	0.0020	1.118	0.02%	0.0192	<10%	yes	93.3
North Lake	0.0000	0.0020	1.118	0.02%	0.0192	<10%	yes	80.9
South Lake	0.0000	0.0020	1.118	0.03%	0.0192	<10%	yes	66.7
Lake Elbert	0.0000	0.0012	1.694	0.01%	0.0078	<10%	yes	56.6
Seven Lakes (LG East)	0.0000	0.0011	1.576	0.02%	0.0079	<10%	yes	36.2
Summit Lake	0.0000	0.0012	1.523	0.02%	0.0082	<10%	yes	48.0
Deep Creek Lake	0.0000	0.0021	0.836	0.13%	0.0265	<1(µeq/L)	yes	20.6
Island Lake	0.0000	0.0012	1.204	0.02%	0.0109	<10%	yes	71.0
Kelly Lake	0.0000	0.0012	1.204	0.01%	0.0109	<10%	yes	179.8
Rawah Lake #4	0.0000	0.0013	1.246	0.03%	0.0112	<10%	yes	41.3
Crater Lake (Sangre de Cristo)	0.0002	0.0111	0.959	0.08%	0.1255	<10%	yes	162.8
Lower Stout Lake	0.0001	0.0063	0.646	0.07%	0.1043	<10%	yes	145.1
Upper Little Sand Creek Lake	0.0001	0.0088	0.803	0.09%	0.1182	<10%	yes	129.4
Upper Stout Lake	0.0001	0.0063	0.646	0.14%	0.1043	<10%	yes	76.2
Glacier Lake (Colorado)	0.0005	0.0264	1.071	0.42%	0.2673	<10%	yes	63.1
Lake South of Blue Lakes	0.0006	0.0335	1.084	1.98%	0.3339	<1(µeq/L)	yes	16.6

Lake	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2025 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Big Eldorado Lake	0.0002	0.0101	1.159	0.48%	0.0943	<1(μeq/L)	yes	19.5
Four Mile Pothole	0.0004	0.0241	0.902	0.23%	0.2888	<10%	yes	123.1
Lake Due South of Ute Lake	0.0003	0.0123	1.106	0.92%	0.1209	<1(μeq/L)	yes	13.0
Little Eldorado	0.0002	0.0101	1.159	2.86%	0.0943	<1(μeq/L)	yes	-3.4
Little Granite Lake	0.0003	0.0147	1.034	0.19%	0.1545	<10%	yes	80.6
Lower Sunlight Lake	0.0003	0.0122	1.136	0.14%	0.1169	<10%	yes	80.7
Middle Ute Lake	0.0003	0.0117	1.110	0.27%	0.1142	<10%	yes	42.7
Small Pond Above Trout Lake	0.0003	0.0165	1.027	0.68%	0.1736	<10%	yes	25.3
Upper Grizzly Lake	0.0003	0.0131	1.199	0.40%	0.1189	<10%	yes	29.8
Upper Sunlight Lake	0.0003	0.0131	1.199	0.42%	0.1189	<10%	yes	27.9
West Snowdon Lake	0.0002	0.0091	0.914	0.27%	0.1082	<10%	yes	39.2
White Dome Lake	0.0002	0.0101	1.159	4.58%	0.0943	<1(μeq/L)	yes	2.0
South Golden Lake	0.0000	0.0028	0.861	0.03%	0.0355	<10%	yes	111.4

Table 7-4. Changes in ANC at sensitive lakes due to FFO emissions for the 2025 Low Development Scenario.

Lake	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2025 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	0.0000	0.0014	1.162	0.01%	0.0129	<10%	yes	101.7
Tabor Lake	0.0000	0.0012	1.182	0.01%	0.0111	<10%	yes	112.4
Booth Lake	0.0000	0.0008	1.223	0.01%	0.0072	<10%	yes	86.8
Upper Willow Lake	0.0000	0.0008	1.143	0.01%	0.0078	<10%	yes	134.1
Ned Wilson Lake	0.0000	0.0007	1.180	0.02%	0.0064	<10%	yes	39.0
Upper Ned Wilson Lake	0.0000	0.0007	1.180	0.05%	0.0064	<1(μeq/L)	yes	12.9
Lower NWL Packtrail Pothole	0.0000	0.0007	1.180	0.02%	0.0064	<10%	yes	29.6
Upper NWL Packtrail Pothole	0.0000	0.0007	1.180	0.01%	0.0064	<10%	yes	48.7
Walk Up Lake	0.0000	0.0001	1.011	0.00%	0.0014	<10%	yes	55.2
Bluebell Lake	0.0000	0.0001	0.943	0.00%	0.0011	<10%	yes	55.5
Dean Lake	0.0000	0.0001	1.024	0.00%	0.0010	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	0.0000	0.0001	0.845	0.00%	0.0019	<10%	yes	67.0
Upper Coffin Lake	0.0000	0.0001	1.047	0.00%	0.0013	<10%	yes	64.8
Fish Lake	0.0000	0.0001	1.062	0.00%	0.0014	<10%	yes	105.8
Blodgett Lake, Colorado	0.0000	0.0010	1.159	0.02%	0.0090	<10%	yes	47.7
Upper Turquoise Lake	0.0000	0.0010	1.121	0.01%	0.0098	<10%	yes	104.0
Upper West Tennessee Lake	0.0000	0.0011	1.161	0.01%	0.0099	<10%	yes	114.2
Blue Lake (Colorado; Boulder - 4E1-040)	0.0000	0.0007	1.348	0.03%	0.0055	<1(μeq/L)	yes	19.2
Crater Lake	0.0000	0.0006	1.241	0.01%	0.0052	<10%	yes	53.1
King Lake (Colorado; Grand - 4E1-049)	0.0000	0.0007	1.237	0.01%	0.0062	<10%	yes	52.3

Lake	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2025 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
No Name Lake (Colorado; Boulder - 4E1-055)	0.0000	0.0008	1.449	0.02%	0.0059	<10%	yes	25.6
Upper Lake	0.0000	0.0006	1.225	0.01%	0.0057	<10%	yes	69.0
Small Lake Above U-Shaped Lake	0.0001	0.0040	0.816	0.09%	0.0524	<10%	yes	59.8
U-Shaped Lake	0.0001	0.0040	0.816	0.06%	0.0524	<10%	yes	81.3
Avalanche Lake	0.0000	0.0015	1.337	0.01%	0.0119	<10%	yes	158.8
Capitol Lake	0.0000	0.0015	1.434	0.01%	0.0117	<10%	yes	154.4
Moon Lake (Upper)	0.0000	0.0015	1.434	0.02%	0.0117	<10%	yes	53.0
Upper Middle Beartrack Lake	0.0000	0.0010	1.018	0.02%	0.0106	<10%	yes	50.9
Abyss Lake	0.0000	0.0010	1.118	0.01%	0.0096	<10%	yes	81.1
Frozen Lake	0.0000	0.0010	1.118	0.01%	0.0096	<10%	yes	93.3
North Lake	0.0000	0.0010	1.118	0.01%	0.0096	<10%	yes	80.9
South Lake	0.0000	0.0010	1.118	0.01%	0.0096	<10%	yes	66.7
Lake Elbert	0.0000	0.0006	1.694	0.01%	0.0038	<10%	yes	56.6
Seven Lakes (LG East)	0.0000	0.0006	1.576	0.01%	0.0039	<10%	yes	36.2
Summit Lake	0.0000	0.0006	1.523	0.01%	0.0041	<10%	yes	48.0
Deep Creek Lake	0.0000	0.0010	0.836	0.06%	0.0134	<1(μeq/L)	yes	20.6
Island Lake	0.0000	0.0006	1.204	0.01%	0.0054	<10%	yes	71.0
Kelly Lake	0.0000	0.0006	1.204	0.00%	0.0054	<10%	yes	179.8
Rawah Lake #4	0.0000	0.0006	1.246	0.01%	0.0056	<10%	yes	41.3
Crater Lake (Sangre de Cristo)	0.0001	0.0055	0.959	0.04%	0.0622	<10%	yes	162.9
Lower Stout Lake	0.0000	0.0031	0.646	0.04%	0.0518	<10%	yes	145.1
Upper Little Sand Creek Lake	0.0001	0.0044	0.803	0.05%	0.0585	<10%	yes	129.4
Upper Stout Lake	0.0000	0.0031	0.646	0.07%	0.0518	<10%	yes	76.3
Glacier Lake (Colorado)	0.0002	0.0132	1.071	0.21%	0.1333	<10%	yes	63.3
Lake South of Blue Lakes	0.0003	0.0167	1.084	0.99%	0.1665	<1(μeq/L)	yes	16.7
Big Eldorado Lake	0.0001	0.0050	1.159	0.24%	0.0470	<1(μeq/L)	yes	19.6

Lake	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2025 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Four Mile Pothole	0.0002	0.0119	0.902	0.12%	0.1434	<10%	yes	123.2
Lake Due South of Ute Lake	0.0001	0.0061	1.106	0.46%	0.0602	<1(μeq/L)	yes	13.1
Little Eldorado	0.0001	0.0050	1.159	1.42%	0.0470	<1(μeq/L)	yes	-3.3
Little Granite Lake	0.0001	0.0073	1.034	0.10%	0.0769	<10%	yes	80.6
Lower Sunlight Lake	0.0001	0.0061	1.136	0.07%	0.0582	<10%	yes	80.8
Middle Ute Lake	0.0001	0.0058	1.110	0.13%	0.0569	<10%	yes	42.7
Small Pond Above Trout Lake	0.0001	0.0082	1.027	0.34%	0.0862	<10%	yes	25.4
Upper Grizzly Lake	0.0002	0.0065	1.199	0.20%	0.0592	<10%	yes	29.8
Upper Sunlight Lake	0.0002	0.0065	1.199	0.21%	0.0592	<10%	yes	27.9
West Snowdon Lake	0.0001	0.0045	0.914	0.14%	0.0537	<10%	yes	39.3
White Dome Lake	0.0001	0.0050	1.159	2.28%	0.0470	<1(μeq/L)	yes	2.0
South Golden Lake	0.0000	0.0014	0.861	0.02%	0.0177	<10%	yes	111.4

Table 7-5. Changes in ANC at sensitive lakes due to FFO emissions for the 2025 Medium Development Scenario.

Lake	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (µeq/L)*	USFS LAC Threshold	Below Thres hold?	2025 Hi Predicted 10th Percentile Lowest ANC Value (µeq/L)
Brooklyn Lake	0.0000	0.0016	1.162	0.01%	0.0148	<10%	yes	101.7
Tabor Lake	0.0000	0.0014	1.182	0.01%	0.0127	<10%	yes	112.4
Booth Lake	0.0000	0.0009	1.223	0.01%	0.0083	<10%	yes	86.8
Upper Willow Lake	0.0000	0.0009	1.143	0.01%	0.0089	<10%	yes	134.1
Ned Wilson Lake	0.0000	0.0008	1.180	0.02%	0.0074	<10%	yes	39.0
Upper Ned Wilson Lake	0.0000	0.0008	1.180	0.06%	0.0074	<1(µeq/L)	yes	12.9
Lower NWL Packtrail Pothole	0.0000	0.0008	1.180	0.02%	0.0074	<10%	yes	29.6
Upper NWL Packtrail Pothole	0.0000	0.0008	1.180	0.02%	0.0074	<10%	yes	48.7
Walk Up Lake	0.0000	0.0002	1.011	0.00%	0.0016	<10%	yes	55.2
Bluebell Lake	0.0000	0.0001	0.943	0.00%	0.0013	<10%	yes	55.5
Dean Lake	0.0000	0.0001	1.024	0.00%	0.0011	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	0.0000	0.0002	0.845	0.00%	0.0021	<10%	yes	67.0
Upper Coffin Lake	0.0000	0.0001	1.047	0.00%	0.0015	<10%	yes	64.8
Fish Lake	0.0000	0.0002	1.062	0.00%	0.0016	<10%	yes	105.8
Blodgett Lake, Colorado	0.0000	0.0011	1.159	0.02%	0.0103	<10%	yes	47.6
Upper Turquoise Lake	0.0000	0.0012	1.121	0.01%	0.0112	<10%	yes	104.0
Upper West Tennessee Lake	0.0000	0.0012	1.161	0.01%	0.0113	<10%	yes	114.2
Blue Lake (Colorado; Boulder - 4E1-040)	0.0000	0.0008	1.348	0.03%	0.0064	<1(µeq/L)	yes	19.2
Crater Lake	0.0000	0.0007	1.241	0.01%	0.0059	<10%	yes	53.1
King Lake (Colorado; Grand - 4E1-049)	0.0000	0.0008	1.237	0.01%	0.0071	<10%	yes	52.3
No Name Lake (Colorado; Boulder - 4E1-055)	0.0000	0.0009	1.449	0.03%	0.0067	<10%	yes	25.6
Upper Lake	0.0000	0.0007	1.225	0.01%	0.0065	<10%	yes	69.0
Small Lake Above U-Shaped Lake	0.0001	0.0045	0.816	0.10%	0.0599	<10%	yes	59.8
U-Shaped Lake	0.0001	0.0045	0.816	0.07%	0.0599	<10%	yes	81.3
Avalanche Lake	0.0000	0.0017	1.337	0.01%	0.0136	<10%	yes	158.8
Capitol Lake	0.0000	0.0018	1.434	0.01%	0.0133	<10%	yes	154.4

Lake	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Thres hold?	2025 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Moon Lake (Upper)	0.0000	0.0018	1.434	0.03%	0.0133	<10%	yes	53.0
Upper Middle Beartrack Lake	0.0000	0.0011	1.018	0.02%	0.0121	<10%	yes	50.9
Abyss Lake	0.0000	0.0011	1.118	0.01%	0.0110	<10%	yes	81.1
Frozen Lake	0.0000	0.0011	1.118	0.01%	0.0110	<10%	yes	93.3
North Lake	0.0000	0.0011	1.118	0.01%	0.0110	<10%	yes	80.9
South Lake	0.0000	0.0011	1.118	0.02%	0.0110	<10%	yes	66.7
Lake Elbert	0.0000	0.0007	1.694	0.01%	0.0044	<10%	yes	56.6
Seven Lakes (LG East)	0.0000	0.0007	1.576	0.01%	0.0045	<10%	yes	36.2
Summit Lake	0.0000	0.0007	1.523	0.01%	0.0047	<10%	yes	48.0
Deep Creek Lake	0.0000	0.0012	0.836	0.07%	0.0151	<1(μeq/L)	yes	20.6
Island Lake	0.0000	0.0007	1.204	0.01%	0.0062	<10%	yes	71.0
Kelly Lake	0.0000	0.0007	1.204	0.00%	0.0062	<10%	yes	179.8
Rawah Lake #4	0.0000	0.0007	1.246	0.02%	0.0064	<10%	yes	41.3
Crater Lake (Sangre de Cristo)	0.0001	0.0063	0.959	0.04%	0.0713	<10%	yes	162.8
Lower Stout Lake	0.0001	0.0035	0.646	0.04%	0.0592	<10%	yes	145.1
Upper Little Sand Creek Lake	0.0001	0.0050	0.803	0.05%	0.0669	<10%	yes	129.4
Upper Stout Lake	0.0001	0.0035	0.646	0.08%	0.0592	<10%	yes	76.3
Glacier Lake (Colorado)	0.0003	0.0150	1.071	0.24%	0.1523	<10%	yes	63.2
Lake South of Blue Lakes	0.0004	0.0190	1.084	1.13%	0.1902	<1(μeq/L)	yes	16.7
Big Eldorado Lake	0.0002	0.0057	1.159	0.27%	0.0537	<1(μeq/L)	yes	19.6
Four Mile Pothole	0.0003	0.0136	0.902	0.13%	0.1638	<10%	yes	123.2
Lake Due South of Ute Lake	0.0002	0.0070	1.106	0.52%	0.0689	<1(μeq/L)	yes	13.1
Little Eldorado	0.0002	0.0057	1.159	1.63%	0.0537	<1(μeq/L)	yes	-3.4
Little Granite Lake	0.0002	0.0083	1.034	0.11%	0.0879	<10%	yes	80.6
Lower Sunlight Lake	0.0002	0.0069	1.136	0.08%	0.0666	<10%	yes	80.8
Middle Ute Lake	0.0002	0.0066	1.110	0.15%	0.0650	<10%	yes	42.7
Small Pond Above Trout Lake	0.0002	0.0093	1.027	0.39%	0.0986	<10%	yes	25.4
Upper Grizzly Lake	0.0002	0.0074	1.199	0.23%	0.0678	<10%	yes	29.8
Upper Sunlight Lake	0.0002	0.0074	1.199	0.24%	0.0678	<10%	yes	27.9
West Snowdon Lake	0.0001	0.0052	0.914	0.16%	0.0614	<10%	yes	39.3
White Dome Lake	0.0002	0.0057	1.159	2.61%	0.0537	<1(μeq/L)	yes	2.0

Lake	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (µeq/L)*	USFS LAC Threshold	Below Thres hold?	2025 Hi Predicted 10th Percentile Lowest ANC Value (µeq/L)
South Golden Lake	0.0000	0.0016	0.861	0.02%	0.0202	<10%	yes	111.4

7.2 ANC Calculations for Cumulative Emissions

Note that the USFS ANC LAC thresholds were developed for evaluating potential changes to lake ANC for individual Projects and are not relevant for cumulative emissions sources. In particular, the baseline ANC values that are used in the ANC change calculations already account for existing emissions. Therefore, no assessment of cumulative impacts to sensitive lakes is presented.

8.0 REFERENCES

EPA. 2007. Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-454/B-07-002. April. (http://www.epa.gov/ttn/scram/guidance/guide/final-03-pm-rh-guidance.pdf).

Grant et al. (2014). Memorandum: Mancos Shale Oil and Gas Emission Calculator Documentation. ENVIRON and Kleinfelder. September 22, 2014. (Included as Appendix E in Vijayaraghavan et al. [2016])

Parker, L. and R. Morris. 2014. Additional CARMMS sensitive Class II areas to accommodate Mancos Shale Development area in north New Mexico. Technical Memorandum. ENVIRON International Corporation, Novato, CA. Prepared for Mary Uhl, BLM New Mexico State Office. August 28.

Ramboll Environ and Kleinfelder, 2016a. Colorado Air Resource Management Modeling Study (CARMMS) with Updated Mancos Shale Modeling: 2021 Modeling Results for the High, Low and Medium Oil and Gas Development Scenarios CARMMS 1.5 Final Report. Novato, CA. March.

USFS. 2000. Screening Methodology for Calculation ANC Change to High Elevation Lakes. USDA Forest Service, Rocky Mountain Region. January. (http://www.fs.fed.us/air/documents/anc_scre.pdf).

FLAG. 2010. Federal Land Managers' Air Quality Related Values Work Group (FLAG) – Phase I Report – Revised (2010). Natural Resource Report NPS/NRPC/NRR – 2012/232. (http://nature.nps.gov/air/pubs/pdf/flag/FLAG_2010.pdf).

Fox, Douglas, Ann M. Bartuska, James G. Byrne, Ellis Cowling, Rich Fisher, Gene E. Likens, Steven E. Lindberg, Rick A. Linthurst, Jay Messer, and Dale S. Nichols. 1989. A Screening Procedure to Evaluate Air Pollution Effects on Class I Wilderness Areas. General Technical Report RM-168. U.S.D.A. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 36 pp.

FWS and NPS. 2012. Letter on Cumulative Visibility Metric Approach from Sandra V. Silva, Chief, Branch of Air Quality, U.S. Fish and Wildlife Service and Carol McCoy, Chief, Air Resource Division, National Park Service to Kelly Bott, Wyoming Department of Environment. February 10.

Vijayaraghavan et al. (2016). Colorado Air Resource Management Modeling Study (CARMMS) with Updated Mancos Shale Modeling: 2021 Modeling Results for the High, Low and Medium Oil and Gas Development Scenarios, CARMMS 1.5 Final Report. Ramboll Environ and Kleinfelder. March 2016. Available at https://www.blm.gov/sites/blm.gov/files/uploads/program_natural%20resources_soil%20air%20water_airco_quick%20link_CARMMS1.5.pdf

Vijayaraghavan et al. (2017). Colorado Air Resource Management Modeling Study (CARMMS): 2025 CAMx Modeling Results for the High, Low and Medium Oil and Gas Development

Scenarios, CARMMS 2.0 Final Report. Ramboll Environ and Kleinfelder. August 2017. Available at https://www.blm.gov/sites/blm.gov/files/documents/files/program_natural%20resources_soil%20air%20water_airco_quicklins_CARMMS2.0.pdf

Production (Downstream/End-Use) Greenhouse Gas Emissions by Alternative

Table J-1
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	41	4,982,000	2.14	238,354,000	13.13	15.28
2019	48	5,451,000	2.34	196,868,000	10.85	13.19
2020	53	5,848,000	2.51	166,017,000	9.15	11.66
2021	59	6,264,000	2.69	144,184,000	7.94	10.64
2022	65	6,653,000	2.86	129,426,000	7.13	9.99
2023	72	7,031,000	3.02	122,031,000	6.72	9.75
2024	78	7,436,000	3.20	117,444,000	6.47	9.67
2025	84	7,876,000	3.39	115,117,000	6.34	9.73
2026	90	8,348,000	3.59	115,655,000	6.37	9.96
2027	96	8,848,000	3.80	118,331,000	6.52	10.32
2028	103	9,366,000	4.03	122,891,000	6.77	10.80
2029	109	9,915,000	4.26	128,793,000	7.10	11.36
2030	112	10,314,000	4.44	134,959,000	7.44	11.87
2031	120	10,939,000	4.70	142,780,000	7.87	12.57
2032	127	11,536,000	4.96	151,268,000	8.33	13.30
2033	133	12,146,000	5.22	160,156,000	8.82	14.05
2034	139	12,779,000	5.49	169,682,000	9.35	14.84
2035	145	13,420,000	5.77	179,496,000	9.89	15.66
2036	150	14,065,000	6.05	190,077,000	10.47	16.52
2037	156	14,688,000	6.32	200,595,000	11.05	17.37
Total	**1,980**	**187,905,000**	**80.80**	**3,044,124,000**	**167.73**	**248.53**
Ave.	**99**	**9,395,250**	**4.04**	**152,206,200**	**8.39**	**12.43**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	67	7,728,000	3.32	378,604,000	20.86	24.18
2019	76	8,405,000	3.61	313,271,000	17.26	20.88
2020	86	8,954,000	3.85	265,002,000	14.60	18.45
2021	96	9,528,000	4.10	231,152,000	12.74	16.83
2022	106	10,063,000	4.33	208,659,000	11.50	15.82
2023	116	10,583,000	4.55	197,789,000	10.90	15.45
2024	126	11,145,000	4.79	191,704,000	10.56	15.36
2025	136	11,762,000	5.06	189,422,000	10.44	15.49
2026	146	12,429,000	5.34	191,739,000	10.56	15.91
2027	156	13,140,000	5.65	197,594,000	10.89	16.54
2028	166	13,932,000	5.99	206,544,000	11.38	17.37
2029	176	14,739,000	6.34	217,656,000	11.99	18.33
2030	180	14,499,000	6.23	229,086,000	12.62	18.86
2031	194	16,006,000	6.88	244,381,000	13.47	20.35
2032	204	17,024,000	7.32	260,365,000	14.35	21.67
2033	214	17,974,000	7.73	276,518,000	15.24	22.96
2034	224	18,965,000	8.15	293,654,000	16.18	24.34
2035	234	19,942,000	8.58	310,443,000	17.11	25.68
2036	244	20,897,000	8.99	330,313,000	18.20	27.19
2037	253	21,846,000	9.39	349,784,000	19.27	28.67
Total	**3,200**	**279,561,000**	**120.21**	**5,083,680,000**	**280.11**	**400.32**
Ave.	**160**	**13,978,050**	**6.01**	**254,184,000**	**14.01**	**20.02**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers

Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons

Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-2
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – No Action Alternative

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	39	4,888,000	2.10	237,795,000	13.10	15.20
2019	44	5,308,000	2.28	195,818,000	10.79	13.07
2020	50	5,663,000	2.44	164,500,000	9.06	11.50
2021	56	6,040,000	2.60	142,178,000	7.83	10.43
2022	62	6,394,000	2.75	126,914,000	6.99	9.74
2023	68	6,739,000	2.90	118,903,000	6.55	9.45
2024	74	7,113,000	3.06	113,762,000	6.27	9.33
2025	80	7,522,000	3.23	110,926,000	6.11	9.35
2026	85	7,962,000	3.42	110,934,000	6.11	9.54
2027	91	8,430,000	3.62	113,067,000	6.23	9.85
2028	97	8,916,000	3.83	117,063,000	6.45	10.28
2029	103	9,432,000	4.06	122,391,000	6.74	10.80
2030	105	9,807,000	4.22	128,016,000	7.05	11.27
2031	114	10,396,000	4.47	135,246,000	7.45	11.92
2032	120	10,961,000	4.71	143,136,000	7.89	12.60
2033	125	11,537,000	4.96	151,426,000	8.34	13.30
2034	131	12,135,000	5.22	160,335,000	8.83	14.05
2035	137	12,742,000	5.48	169,529,000	9.34	14.82
2036	143	13,353,000	5.74	179,460,000	9.89	15.63
2037	149	13,943,000	6.00	189,339,000	10.43	16.43
Total	**1,873**	**179,281,000**	**77.09**	**2,930,738,000**	**161.48**	**238.57**
Ave.	**93.65**	**8,964,050**	**3.85**	**146,536,900**	**8.07**	**11.93**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	65	7,590,000	3.32	378,038,000	20.83	24.15
2019	73	8,174,000	3.61	312,259,000	17.21	20.82
2020	83	8,671,000	3.85	263,641,000	14.53	18.38
2021	93	9,206,000	4.10	229,439,000	12.64	16.74
2022	102	9,714,000	4.33	206,563,000	11.38	15.71
2023	112	10,214,000	4.55	195,139,000	10.75	15.30
2024	122	10,762,000	4.79	188,564,000	10.39	15.18
2025	131	11,364,000	5.06	185,889,000	10.24	15.30
2026	141	12,016,000	5.34	187,774,000	10.35	15.69
2027	151	12,713,000	5.65	193,142,000	10.64	16.29
2028	160	13,438,000	5.99	201,540,000	11.10	17.10
2029	170	14,211,000	6.34	212,115,000	11.69	18.03
2030	174	14,775,000	6.23	223,172,000	12.30	18.53
2031	188	15,660,000	6.88	236,847,000	13.05	19.93
2032	197	16,509,000	7.32	251,635,000	13.87	21.19
2033	207	17,378,000	7.73	267,145,000	14.72	22.45
2034	217	18,280,000	8.15	283,733,000	15.63	23.79
2035	226	19,195,000	8.58	300,851,000	16.58	25.15
2036	236	20,118,000	8.99	319,167,000	17.59	26.57
2037	245	21,010,000	9.39	337,475,000	18.59	27.99
Total	**3,093**	**270,998,000**	**116.53**	**4,974,128,000**	**274.07**	**390.60**
Ave.	**155**	**13,549,900**	**6.01**	**248,706,400**	**13.70**	**19.71**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers
Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons
Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-3
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative A

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	29	4,489,000	1.93	235,320,000	12.97	14.90
2019	33	4,698,000	2.02	191,151,000	10.53	12.55
2020	38	4,876,000	2.10	157,725,000	8.69	10.79
2021	42	5,085,000	2.19	133,200,000	7.34	9.53
2022	46	5,290,000	2.27	115,643,000	6.37	8.65
2023	51	5,498,000	2.36	104,867,000	5.78	8.14
2024	55	5,738,000	2.47	97,215,000	5.36	7.82
2025	59	6,012,000	2.59	92,046,000	5.07	7.66
2026	64	6,316,000	2.72	89,628,000	4.94	7.65
2027	68	6,647,000	2.86	89,272,000	4.92	7.78
2028	73	6,997,000	3.01	90,682,000	5.00	8.01
2029	77	7,374,000	3.17	93,375,000	5.14	8.32
2030	79	7,644,000	3.29	96,515,000	5.32	8.60
2031	85	8,084,000	3.48	101,031,000	5.57	9.04
2032	89	8,505,000	3.66	106,171,000	5.85	9.51
2033	94	8,938,000	3.84	111,707,000	6.16	10.00
2034	98	9,390,000	4.04	117,777,000	6.49	10.53
2035	102	9,849,000	4.24	124,114,000	6.84	11.07
2036	107	10,313,000	4.43	131,055,000	7.22	11.66
2037	110	10,761,000	4.63	137,982,000	7.60	12.23
Total	**1,399**	**142,504,000**	**61.28**	**2,416,476,000**	**133.15**	**194.42**
Ave.	**69.95**	**7,125,200**	**3.06**	**120,823,800**	**6.66**	**9.72**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	55	7,190,000	3.09	375,563,000	20.69	23.79
2019	62	7,564,000	3.25	307,592,000	16.95	20.20
2020	70	7,884,000	3.39	256,866,000	14.15	17.54
2021	79	8,252,000	3.55	220,461,000	12.15	15.70
2022	87	8,610,000	3.70	195,292,000	10.76	14.46
2023	95	8,973,000	3.86	181,103,000	9.98	13.84
2024	103	9,386,000	4.04	172,017,000	9.48	13.51
2025	111	9,854,000	4.24	167,008,000	9.20	13.44
2026	119	10,370,000	4.46	166,467,000	9.17	13.63
2027	128	10,930,000	4.70	169,347,000	9.33	14.03
2028	136	11,520,000	4.95	175,158,000	9.65	14.60
2029	144	12,153,000	5.23	183,099,000	10.09	15.31
2030	147	12,612,000	5.42	191,670,000	10.56	15.98
2031	159	13,347,000	5.74	202,632,000	11.17	16.90
2032	167	14,054,000	6.04	214,671,000	11.83	17.87
2033	175	14,779,000	6.35	227,425,000	12.53	18.89
2034	183	15,535,000	6.68	241,175,000	13.29	19.97
2035	192	16,302,000	7.01	255,436,000	14.07	21.08
2036	200	17,078,000	7.34	270,762,000	14.92	22.26
2037	207	17,828,000	7.67	286,119,000	15.77	23.43
Total	**2,619**	**234,221,000**	**100.72**	**4,459,863,000**	**245.74**	**346.45**
Ave.	**131**	**11,711,050**	**5.04**	**222,993,150**	**12.29**	**17.32**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers

Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons

Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-4
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative B1

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	29	4,460,000	1.92	235,331,000	12.97	14.88
2019	33	4,656,000	2.00	191,210,000	10.54	12.54
2020	38	4,822,000	2.07	157,861,000	8.70	10.77
2021	42	5,020,000	2.16	133,426,000	7.35	9.51
2022	46	5,215,000	2.24	115,972,000	6.39	8.63
2023	51	5,415,000	2.33	105,281,000	5.80	8.13
2024	55	5,646,000	2.43	97,753,000	5.39	7.81
2025	60	5,912,000	2.54	92,740,000	5.11	7.65
2026	64	6,208,000	2.67	90,480,000	4.99	7.65
2027	68	6,531,000	2.81	90,295,000	4.98	7.78
2028	73	6,872,000	2.95	91,880,000	5.06	8.02
2029	77	7,241,000	3.11	94,756,000	5.22	8.33
2030	79	7,505,000	3.23	98,083,000	5.40	8.63
2031	85	7,935,000	3.41	102,789,000	5.66	9.08
2032	89	8,349,000	3.59	108,125,000	5.96	9.55
2033	94	8,773,000	3.77	113,866,000	6.27	10.05
2034	98	9,216,000	3.96	120,152,000	6.62	10.58
2035	103	9,666,000	4.16	126,713,000	6.98	11.14
2036	107	10,121,000	4.35	133,877,000	7.38	11.73
2037	111	10,561,000	4.54	141,037,000	7.77	12.31
Total	**1,402**	**140,124,000**	**60.25**	**2,441,627,000**	**134.53**	**194.79**
Ave.	**70.10**	**7,006,200**	**3.01**	**122,081,350**	**6.73**	**9.74**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	55	7,162,000	3.08	375,574,000	20.69	23.77
2019	62	7,522,000	3.23	307,651,000	16.95	20.19
2020	70	7,830,000	3.37	257,002,000	14.16	17.53
2021	79	8,187,000	3.52	220,687,000	12.16	15.68
2022	87	8,535,000	3.67	195,621,000	10.78	14.45
2023	95	8,890,000	3.82	181,517,000	10.00	13.82
2024	103	9,295,000	4.00	172,555,000	9.51	13.50
2025	111	9,754,000	4.19	167,702,000	9.24	13.43
2026	120	10,262,000	4.41	167,320,000	9.22	13.63
2027	128	10,814,000	4.65	170,370,000	9.39	14.04
2028	136	11,395,000	4.90	176,357,000	9.72	14.62
2029	144	12,020,000	5.17	184,480,000	10.16	15.33
2030	147	12,473,000	5.36	193,238,000	10.65	16.01
2031	159	13,199,000	5.68	204,390,000	11.26	16.94
2032	167	13,897,000	5.98	216,624,000	11.94	17.91
2033	175	14,614,000	6.28	229,585,000	12.65	18.93
2034	184	15,361,000	6.61	243,550,000	13.42	20.02
2035	192	16,120,000	6.93	258,035,000	14.22	21.15
2036	200	16,886,000	7.26	273,584,000	15.07	22.34
2037	208	17,628,000	7.58	289,174,000	15.93	23.51
Total	**2,622**	**231,844,000**	**99.69**	**4,485,016,000**	**247.12**	**346.82**
Ave.	**131**	**11,592,200**	**4.98**	**224,250,800**	**12.36**	**17.34**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers
Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons
Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-5
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative B2

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	23	4,159,000	1.79	233,874,000	12.89	14.67
2019	28	4,198,000	1.81	188,547,000	10.39	12.19
2020	30	4,232,000	1.82	154,106,000	8.49	10.31
2021	33	4,306,000	1.85	128,552,000	7.08	8.93
2022	36	4,391,000	1.89	109,952,000	6.06	7.95
2023	41	4,490,000	1.93	97,793,000	5.39	7.32
2024	44	4,623,000	1.99	89,036,000	4.91	6.89
2025	48	4,789,000	2.06	82,970,000	4.57	6.63
2026	51	4,986,000	2.14	79,608,000	4.39	6.53
2027	54	5,209,000	2.24	78,307,000	4.31	6.55
2028	59	5,450,000	2.34	78,732,000	4.34	6.68
2029	62	5,716,000	2.46	80,433,000	4.43	6.89
2030	66	5,906,000	2.54	82,683,000	4.56	7.10
2031	68	6,226,000	2.68	86,182,000	4.75	7.43
2032	72	6,535,000	2.81	90,306,000	4.98	7.79
2033	76	6,855,000	2.95	94,851,000	5.23	8.17
2034	79	7,191,000	3.09	99,911,000	5.51	8.60
2035	82	7,534,000	3.24	105,255,000	5.80	9.04
2036	85	7,881,000	3.39	111,122,000	6.12	9.51
2037	88	8,218,000	3.53	117,029,000	6.45	9.98
Total	**1,980**	**112,895,000**	**48.54**	**2,189,249,000**	**120.63**	**169.17**
Ave.	**56**	**5,644,750**	**2.43**	**109,462,450**	**6.03**	**8.46**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	49	6,861,000	2.95	374,118,000	20.61	23.56
2019	56	7,064,000	3.04	304,988,000	16.80	19.84
2020	63	7,240,000	3.11	253,247,000	13.95	17.07
2021	70	7,473,000	3.21	215,813,000	11.89	15.10
2022	77	7,711,000	3.32	189,601,000	10.45	13.76
2023	85	7,965,000	3.42	174,030,000	9.59	13.01
2024	92	8,271,000	3.56	163,838,000	9.03	12.58
2025	100	8,631,000	3.71	157,932,000	8.70	12.41
2026	107	9,040,000	3.89	156,447,000	8.62	12.51
2027	114	9,491,000	4.08	158,382,000	8.73	12.81
2028	122	9,973,000	4.29	163,209,000	8.99	13.28
2029	129	10,496,000	4.51	170,157,000	9.38	13.89
2030	134	10,874,000	4.68	177,838,000	9.80	14.47
2031	142	11,490,000	4.94	187,784,000	10.35	15.29
2032	149	12,084,000	5.20	198,805,000	10.95	16.15
2033	157	12,696,000	5.46	210,570,000	11.60	17.06
2034	164	13,335,000	5.73	223,310,000	12.30	18.04
2035	171	13,987,000	6.01	236,577,000	13.04	19.05
2036	179	14,646,000	6.30	250,828,000	13.82	20.12
2037	185	15,286,000	6.57	265,166,000	14.61	21.18
Total	**2,345**	**204,614,000**	**87.98**	**4,232,640,000**	**233.22**	**321.20**
Ave.	**117**	**10,230,700**	**4.40**	**211,632,000**	**11.66**	**16.06**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers
Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons
Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-6
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative C1

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	39	4,883,000	2.10	237,753,000	13.10	15.20
2019	44	5,300,000	2.28	195,737,000	10.79	13.06
2020	50	5,653,000	2.43	164,380,000	9.06	11.49
2021	56	6,028,000	2.59	142,016,000	7.83	10.42
2022	62	6,380,000	2.74	126,708,000	6.98	9.73
2023	68	6,724,000	2.89	118,646,000	6.54	9.43
2024	73	7,096,000	3.05	113,456,000	6.25	9.30
2025	79	7,503,000	3.23	110,572,000	6.09	9.32
2026	85	7,941,000	3.41	110,531,000	6.09	9.50
2027	91	8,408,000	3.62	112,612,000	6.20	9.82
2028	97	8,892,000	3.82	116,555,000	6.42	10.25
2029	103	9,406,000	4.04	121,828,000	6.71	10.76
2030	105	9,779,000	4.20	127,401,000	7.02	11.22
2031	113	10,367,000	4.46	134,574,000	7.42	11.87
2032	119	10,930,000	4.70	142,407,000	7.85	12.55
2033	125	11,504,000	4.95	150,639,000	8.30	13.25
2034	131	12,101,000	5.20	159,488,000	8.79	13.99
2035	136	12,705,000	5.46	168,621,000	9.29	14.75
2036	142	13,314,000	5.73	178,490,000	9.83	15.56
2037	147	13,902,000	5.98	188,305,000	10.38	16.35
Total	**1,865**	**178,816,000**	**76.89**	**2,920,719,000**	**160.93**	**237.82**
Ave.	**93.25**	**8,940,800**	**3.84**	**146,035,950**	**8.05**	**11.89**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	65	7,585,000	3.26	377,997,000	20.83	24.09
2019	73	8,167,000	3.51	312,179,000	17.20	20.71
2020	83	8,662,000	3.72	263,521,000	14.52	18.24
2021	93	9,194,000	3.95	229,277,000	12.63	16.59
2022	102	9,700,000	4.17	206,357,000	11.37	15.54
2023	112	10,199,000	4.39	194,883,000	10.74	15.12
2024	121	10,744,000	4.62	188,258,000	10.37	14.99
2025	131	11,345,000	4.88	185,535,000	10.22	15.10
2026	141	11,996,000	5.16	187,370,000	10.32	15.48
2027	150	12,690,000	5.46	192,687,000	10.62	16.07
2028	160	13,414,000	5.77	201,031,000	11.08	16.84
2029	170	14,186,000	6.10	211,552,000	11.66	17.76
2030	174	14,748,000	6.34	222,556,000	12.26	18.60
2031	187	15,631,000	6.72	236,176,000	13.01	19.73
2032	197	16,478,000	7.09	250,906,000	13.82	20.91
2033	206	17,345,000	7.46	266,357,000	14.68	22.13
2034	216	18,245,000	7.85	282,886,000	15.59	23.43
2035	226	19,159,000	8.24	299,943,000	16.53	24.77
2036	235	20,080,000	8.63	318,196,000	17.53	26.17
2037	243	20,970,000	9.02	336,442,000	18.54	27.56
Total	**3,085**	**270,538,000**	**116.33**	**4,964,109,000**	**273.52**	**389.85**
Ave.	**154**	**13,526,900**	**5.82**	**248,205,450**	**13.68**	**19.49**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers

Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons

Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-7
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative C2

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	39	4,882,000	2.10	237,738,000	13.10	15.20
2019	44	5,298,000	2.28	195,707,000	10.78	13.06
2020	50	5,651,000	2.43	164,333,000	9.05	11.48
2021	56	6,025,000	2.59	141,952,000	7.82	10.41
2022	62	6,376,000	2.74	126,626,000	6.98	9.72
2023	67	6,720,000	2.89	118,544,000	6.53	9.42
2024	73	7,092,000	3.05	113,334,000	6.24	9.29
2025	79	7,498,000	3.22	110,429,000	6.08	9.31
2026	85	7,936,000	3.41	110,367,000	6.08	9.49
2027	91	8,402,000	3.61	112,426,000	6.19	9.81
2028	97	8,885,000	3.82	116,346,000	6.41	10.23
2029	102	9,399,000	4.04	121,595,000	6.70	10.74
2030	105	9,772,000	4.20	127,146,000	7.01	11.21
2031	113	10,359,000	4.45	134,295,000	7.40	11.85
2032	119	10,921,000	4.70	142,103,000	7.83	12.53
2033	125	11,495,000	4.94	150,310,000	8.28	13.22
2034	130	12,091,000	5.20	159,133,000	8.77	13.97
2035	136	12,695,000	5.46	168,240,000	9.27	14.73
2036	142	13,304,000	5.72	178,081,000	9.81	15.53
2037	147	13,891,000	5.97	187,869,000	10.35	16.32
Total	**1,862**	**178,692,000**	**76.84**	**2,916,574,000**	**160.70**	**237.54**
Ave.	**93.10**	**8,934,600**	**3.84**	**145,828,700**	**8.04**	**11.88**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	65	7,584,000	3.26	377,981,000	20.83	24.09
2019	73	8,165,000	3.51	312,148,000	17.20	20.71
2020	83	8,659,000	3.72	263,474,000	14.52	18.24
2021	92	9,191,000	3.95	229,213,000	12.63	16.58
2022	102	9,696,000	4.17	206,275,000	11.37	15.54
2023	112	10,195,000	4.38	194,780,000	10.73	15.12
2024	121	10,740,000	4.62	188,136,000	10.37	14.98
2025	131	11,340,000	4.88	185,392,000	10.22	15.09
2026	141	11,990,000	5.16	187,206,000	10.32	15.47
2027	150	12,684,000	5.45	192,501,000	10.61	16.06
2028	160	13,408,000	5.77	200,822,000	11.07	16.83
2029	170	14,178,000	6.10	211,320,000	11.64	17.74
2030	173	14,740,000	6.34	222,301,000	12.25	18.59
2031	187	15,623,000	6.72	235,897,000	13.00	19.72
2032	196	16,470,000	7.08	250,602,000	13.81	20.89
2033	206	17,336,000	7.45	266,028,000	14.66	22.11
2034	216	18,236,000	7.84	282,531,000	15.57	23.41
2035	225	19,149,000	8.23	299,562,000	16.51	24.74
2036	235	20,069,000	8.63	317,787,000	17.51	26.14
2037	244	20,959,000	9.01	336,005,000	18.51	27.53
Total	**3,082**	**270,412,000**	**116.28**	**4,959,961,000**	**273.29**	**389.57**
Ave.	**154**	**13,520,600**	**5.81**	**247,998,050**	**13.66**	**19.48**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers
Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons
Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-8
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative C3

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	39	4,882,000	2.10	237,722,000	13.10	15.20
2019	44	5,298,000	2.28	195,675,000	10.78	13.06
2020	50	5,650,000	2.43	164,283,000	9.05	11.48
2021	56	6,024,000	2.59	141,882,000	7.82	10.41
2022	62	6,375,000	2.74	126,535,000	6.97	9.71
2023	67	6,719,000	2.89	118,430,000	6.53	9.41
2024	73	7,090,000	3.05	113,196,000	6.24	9.29
2025	79	7,497,000	3.22	110,266,000	6.08	9.30
2026	85	7,935,000	3.41	110,177,000	6.07	9.48
2027	91	8,400,000	3.61	112,209,000	6.18	9.79
2028	96	8,884,000	3.82	116,100,000	6.40	10.22
2029	102	9,397,000	4.04	121,320,000	6.68	10.73
2030	105	9,770,000	4.20	126,842,000	6.99	11.19
2031	113	10,357,000	4.45	133,961,000	7.38	11.83
2032	119	10,919,000	4.70	141,738,000	7.81	12.50
2033	124	11,492,000	4.94	149,913,000	8.26	13.20
2034	130	12,088,000	5.20	158,703,000	8.74	13.94
2035	136	12,692,000	5.46	167,776,000	9.24	14.70
2036	142	13,301,000	5.72	177,583,000	9.78	15.50
2037	147	13,888,000	5.97	187,335,000	10.32	16.29
Total	**1,860**	**178,658,000**	**76.82**	**2,911,646,000**	**160.43**	**237.25**
Ave.	**93.00**	**8,932,900**	**3.84**	**145,582,300**	**8.02**	**11.86**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	64	7,583,000	3.26	377,966,000	20.83	24.09
2019	73	8,164,000	3.51	312,116,000	17.20	20.71
2020	83	8,659,000	3.72	263,424,000	14.51	18.24
2021	92	9,191,000	3.95	229,144,000	12.63	16.58
2022	102	9,696,000	4.17	206,184,000	11.36	15.53
2023	112	10,194,000	4.38	194,667,000	10.73	15.11
2024	121	10,739,000	4.62	187,998,000	10.36	14.98
2025	131	11,339,000	4.88	185,229,000	10.21	15.08
2026	140	11,989,000	5.16	187,016,000	10.30	15.46
2027	150	12,683,000	5.45	192,284,000	10.59	16.05
2028	160	13,406,000	5.76	200,577,000	11.05	16.82
2029	169	14,177,000	6.10	211,045,000	11.63	17.72
2030	173	14,738,000	6.34	221,997,000	12.23	18.57
2031	187	15,621,000	6.72	235,562,000	12.98	19.70
2032	196	16,467,000	7.08	250,237,000	13.79	20.87
2033	206	17,333,000	7.45	265,632,000	14.64	22.09
2034	216	18,233,000	7.84	282,101,000	15.54	23.38
2035	225	19,146,000	8.23	299,098,000	16.48	24.71
2036	235	20,066,000	8.63	317,289,000	17.48	26.11
2037	244	20,955,000	9.01	335,472,000	18.48	27.50
Total	**3,079**	**270,379,000**	**116.26**	**4,955,038,000**	**273.02**	**389.29**
Ave.	**154**	**13,518,950**	**5.81**	**247,751,900**	**13.65**	**19.46**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers
Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons
Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-9
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative C4

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	39	4,879,000	2.10	237,707,000	13.10	15.20
2019	44	5,294,000	2.28	195,645,000	10.78	13.06
2020	50	5,646,000	2.43	164,240,000	9.05	11.48
2021	56	6,018,000	2.59	141,825,000	7.81	10.40
2022	61	6,369,000	2.74	126,462,000	6.97	9.71
2023	67	6,712,000	2.89	118,340,000	6.52	9.41
2024	73	7,082,000	3.05	113,089,000	6.23	9.28
2025	79	7,488,000	3.22	110,144,000	6.07	9.29
2026	85	7,925,000	3.41	110,038,000	6.06	9.47
2027	90	8,389,000	3.61	112,054,000	6.17	9.78
2028	96	8,872,000	3.81	115,928,000	6.39	10.20
2029	102	9,385,000	4.04	121,131,000	6.67	10.71
2030	104	9,757,000	4.20	126,636,000	6.98	11.17
2031	113	10,343,000	4.45	133,737,000	7.37	11.82
2032	118	10,904,000	4.69	141,495,000	7.80	12.49
2033	124	11,477,000	4.94	149,652,000	8.25	13.18
2034	130	12,072,000	5.19	158,423,000	8.73	13.92
2035	136	12,675,000	5.45	167,477,000	9.23	14.68
2036	142	13,282,000	5.71	177,263,000	9.77	15.48
2037	147	13,869,000	5.96	186,996,000	10.30	16.27
Total	**1,856**	**178,438,000**	**76.73**	**2,908,282,000**	**160.25**	**236.97**
Ave.	**92.80**	**8,921,900**	**3.84**	**145,414,100**	**8.01**	**11.85**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	64	7,581,000	3.26	377,950,000	20.83	24.08
2019	73	8,161,000	3.51	312,087,000	17.20	20.71
2020	83	8,654,000	3.72	263,381,000	14.51	18.23
2021	92	9,185,000	3.95	229,086,000	12.62	16.57
2022	102	9,689,000	4.17	206,112,000	11.36	15.52
2023	112	10,187,000	4.38	194,576,000	10.72	15.10
2024	121	10,731,000	4.61	187,891,000	10.35	14.97
2025	131	11,330,000	4.87	185,106,000	10.20	15.07
2026	140	11,979,000	5.15	186,878,000	10.30	15.45
2027	150	12,672,000	5.45	192,129,000	10.59	16.04
2028	160	13,395,000	5.76	200,404,000	11.04	16.80
2029	169	14,164,000	6.09	210,855,000	11.62	17.71
2030	173	14,725,000	6.33	221,791,000	12.22	18.55
2031	186	15,607,000	6.71	235,338,000	12.97	19.68
2032	196	16,453,000	7.07	249,994,000	13.77	20.85
2033	206	17,318,000	7.45	265,370,000	14.62	22.07
2034	215	18,217,000	7.83	281,821,000	15.53	23.36
2035	225	19,128,000	8.23	298,799,000	16.46	24.69
2036	235	20,048,000	8.62	316,970,000	17.47	26.09
2037	243	20,936,000	9.00	335,133,000	18.47	27.47
Total	**3,076**	**270,160,000**	**116.17**	**4,951,671,000**	**272.84**	**389.01**
Ave.	**154**	**13,508,000**	**5.81**	**247,583,550**	**13.64**	**19.45**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers
Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons
Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-11
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative C5

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	39	4,876,000	2.10	237,665,000	13.10	15.19
2019	44	5,288,000	2.27	195,563,000	10.78	13.05
2020	50	5,638,000	2.42	164,116,000	9.04	11.47
2021	55	6,009,000	2.58	141,657,000	7.81	10.39
2022	61	6,358,000	2.73	126,247,000	6.96	9.69
2023	67	6,699,000	2.88	118,071,000	6.51	9.39
2024	73	7,069,000	3.04	112,768,000	6.21	9.25
2025	79	7,473,000	3.21	109,769,000	6.05	9.26
2026	84	7,908,000	3.40	109,609,000	6.04	9.44
2027	90	8,372,000	3.60	111,568,000	6.15	9.75
2028	96	8,853,000	3.81	115,383,000	6.36	10.16
2029	102	9,364,000	4.03	120,525,000	6.64	10.67
2030	104	9,735,000	4.19	125,972,000	6.94	11.13
2031	112	10,320,000	4.44	133,010,000	7.33	11.77
2032	118	10,879,000	4.68	140,705,000	7.75	12.43
2033	124	11,451,000	4.92	148,797,000	8.20	13.12
2034	129	12,044,000	5.18	157,501,000	8.68	13.86
2035	135	12,646,000	5.44	166,487,000	9.17	14.61
2036	141	13,251,000	5.70	176,203,000	9.71	15.41
2037	145	13,836,000	5.95	185,866,000	10.24	16.19
Total	**1,848**	**178,069,000**	**76.57**	**2,897,482,000**	**159.65**	**236.22**
Ave.	**92.40**	**8,903,450**	**3.83**	**144,874,100**	**7.98**	**11.81**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	64	7,577,000	3.26	377,909,000	20.82	24.08
2019	73	8,155,000	3.51	312,005,000	17.19	20.70
2020	82	8,646,000	3.72	263,257,000	14.51	18.22
2021	92	9,176,000	3.95	228,918,000	12.61	16.56
2022	102	9,678,000	4.16	205,896,000	11.34	15.51
2023	111	10,174,000	4.37	194,308,000	10.71	15.08
2024	121	10,717,000	4.61	187,570,000	10.34	14.94
2025	130	11,315,000	4.87	184,732,000	10.18	15.04
2026	140	11,963,000	5.14	186,449,000	10.27	15.42
2027	150	12,654,000	5.44	191,643,000	10.56	16.00
2028	159	13,376,000	5.75	199,859,000	11.01	16.76
2029	169	14,144,000	6.08	210,249,000	11.58	17.67
2030	173	14,704,000	6.32	221,127,000	12.18	18.51
2031	186	15,584,000	6.70	234,611,000	12.93	19.63
2032	196	16,428,000	7.06	249,204,000	13.73	20.80
2033	205	17,291,000	7.44	264,515,000	14.57	22.01
2034	215	18,189,000	7.82	280,899,000	15.48	23.30
2035	224	19,099,000	8.21	297,809,000	16.41	24.62
2036	234	20,017,000	8.61	315,910,000	17.41	26.01
2037	242	20,904,000	8.99	334,002,000	18.40	27.39
Total	**3,068**	**269,791,000**	**116.01**	**4,940,872,000**	**272.24**	**388.25**
Ave.	**153**	**13,489,550**	**5.80**	**247,043,600**	**13.61**	**19.41**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers
Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons
Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-12
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative C6

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	39	4,878,000	2.10	237,691,000	13.10	15.19
2019	44	5,292,000	2.28	195,614,000	10.78	13.05
2020	50	5,643,000	2.43	164,193,000	9.05	11.47
2021	56	6,015,000	2.59	141,761,000	7.81	10.40
2022	61	6,365,000	2.74	126,381,000	6.96	9.70
2023	67	6,707,000	2.88	118,238,000	6.51	9.40
2024	73	7,078,000	3.04	112,967,000	6.22	9.27
2025	79	7,483,000	3.22	110,001,000	6.06	9.28
2026	85	7,919,000	3.41	109,874,000	6.05	9.46
2027	90	8,383,000	3.60	111,868,000	6.16	9.77
2028	96	8,866,000	3.81	115,719,000	6.38	10.19
2029	102	9,378,000	4.03	120,898,000	6.66	10.69
2030	104	9,750,000	4.19	126,381,000	6.96	11.16
2031	112	10,335,000	4.44	133,457,000	7.35	11.80
2032	118	10,895,000	4.68	141,191,000	7.78	12.46
2033	124	11,468,000	4.93	149,322,000	8.23	13.16
2034	130	12,062,000	5.19	158,068,000	8.71	13.90
2035	135	12,665,000	5.45	167,095,000	9.21	14.65
2036	141	13,272,000	5.71	176,855,000	9.74	15.45
2037	147	13,857,000	5.96	186,560,000	10.28	16.24
Total	**1,853**	**178,311,000**	**76.67**	**2,904,134,000**	**160.02**	**236.69**
Ave.	**92.65**	**8,915,550**	**3.83**	**145,206,700**	**8.00**	**11.83**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	64	7,580,000	3.26	377,935,000	20.82	24.08
2019	73	8,159,000	3.51	312,056,000	17.19	20.70
2020	83	8,651,000	3.72	263,334,000	14.51	18.23
2021	92	9,182,000	3.95	229,022,000	12.62	16.57
2022	102	9,685,000	4.16	206,030,000	11.35	15.52
2023	111	10,182,000	4.38	194,474,000	10.72	15.09
2024	121	10,726,000	4.61	187,769,000	10.35	14.96
2025	131	11,325,000	4.87	184,963,000	10.19	15.06
2026	140	11,973,000	5.15	186,714,000	10.29	15.44
2027	150	12,666,000	5.45	191,943,000	10.58	16.02
2028	159	13,388,000	5.76	200,195,000	11.03	16.79
2029	169	14,157,000	6.09	210,623,000	11.61	17.69
2030	173	14,718,000	6.33	221,536,000	12.21	18.54
2031	186	15,599,000	6.71	235,059,000	12.95	19.66
2032	196	16,444,000	7.07	249,690,000	13.76	20.83
2033	206	17,309,000	7.44	265,041,000	14.60	22.05
2034	215	18,207,000	7.83	281,466,000	15.51	23.34
2035	225	19,118,000	8.22	298,417,000	16.44	24.66
2036	234	20,037,000	8.62	316,561,000	17.44	26.06
2037	243	20,925,000	9.00	334,697,000	18.44	27.44
Total	**3,073**	**270,031,000**	**116.11**	**4,947,525,000**	**272.61**	**388.72**
Ave.	**154**	**13,501,550**	**5.81**	**247,376,250**	**13.63**	**19.44**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers
Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons
Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

Table J-13
Production (Downstream/End-Use) GHG Emissions from Federal and Cumulative Oil and Gas Production, Baseline RFD Scenario – Alternative D

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Federal Wells in the Planning Area (non-BIA)						
2018	39	4,894,000	2.10	237,836,000	13.10	15.21
2019	45	5,317,000	2.29	195,897,000	10.79	13.08
2020	51	5,675,000	2.44	164,616,000	9.07	11.51
2021	56	6,054,000	2.60	142,334,000	7.84	10.45
2022	62	6,410,000	2.76	127,111,000	7.00	9.76
2023	68	6,758,000	2.91	119,148,000	6.57	9.47
2024	74	7,134,000	3.07	114,053,000	6.28	9.35
2025	80	7,545,000	3.24	111,259,000	6.13	9.37
2026	86	7,987,000	3.43	111,312,000	6.13	9.57
2027	92	8,457,000	3.64	113,491,000	6.25	9.89
2028	98	8,945,000	3.85	117,535,000	6.48	10.32
2029	103	9,463,000	4.07	122,911,000	6.77	10.84
2030	106	9,839,000	4.23	128,583,000	7.08	11.32
2031	114	10,431,000	4.49	135,863,000	7.49	11.97
2032	120	10,998,000	4.73	143,804,000	7.92	12.65
2033	126	11,576,000	4.98	152,145,000	8.38	13.36
2034	132	12,177,000	5.24	161,107,000	8.88	14.11
2035	138	12,786,000	5.50	170,355,000	9.39	14.88
2036	143	13,399,000	5.76	180,342,000	9.94	15.70
2037	148	13,991,000	6.02	190,275,000	10.48	16.50
Total	**1,881**	**179,836,000**	**77.33**	**2,939,977,000**	**161.99**	**239.32**
Ave.	**94.05**	**8,991,800**	**3.87**	**146,998,850**	**8.10**	**11.97**
BIA Wells in the Planning Area						
2018	11	1,268,776	0.55	62,158,866	3.42	3.97
2019	12	1,327,105	0.57	49,463,842	2.73	3.30
2020	14	1,457,628	0.63	43,139,860	2.38	3.00
2021	15	1,488,750	0.64	36,117,500	1.99	2.63
2022	17	1,613,877	0.69	33,464,179	1.84	2.54
2023	18	1,642,190	0.71	30,691,397	1.69	2.40
2024	20	1,769,048	0.76	30,429,206	1.68	2.44
2025	22	1,902,676	0.82	30,641,794	1.69	2.51
2026	23	1,957,993	0.84	30,205,459	1.66	2.51
2027	25	2,105,769	0.91	31,665,705	1.74	2.65
2028	26	2,182,120	0.94	32,350,265	1.78	2.72
2029	28	2,344,841	1.01	34,627,091	1.91	2.92
2030	29	2,335,950	1.00	36,908,300	2.03	3.04
2031	31	2,557,660	1.10	39,050,572	2.15	3.25
2032	33	2,753,882	1.18	42,117,868	2.32	3.50
2033	34	2,855,682	1.23	43,932,766	2.42	3.65
2034	36	3,047,946	1.31	47,194,393	2.60	3.91
2035	37	3,153,222	1.36	49,087,141	2.70	4.06
2036	39	3,340,094	1.44	52,795,930	2.91	4.35
2037	40	3,453,913	1.49	55,301,818	3.05	4.53
Total	**510**	**44,559,125**	**19.16**	**811,343,953**	**44.71**	**63.87**

Year	Total Wells	Annual Oil Production (bbl)	Downstream Emissions—Oil (MMt CO_2)	Annual Gas Production (mcf)	Downstream Emissions—Gas (MMt CO_2)	Total Oil and Gas Emissions (MMt CO_2)
Ave.	**26**	**2,227,956**	**0.96**	**40,567,198**	**2.24**	**3.19**
All Wells in the Planning Area (Federal and Nonfederal)						
2018	65	7,596,000	3.27	378,080,000	20.83	24.10
2019	74	8,183,000	3.52	312,339,000	17.21	20.73
2020	83	8,683,000	3.73	263,757,000	14.53	18.27
2021	93	9,221,000	3.97	229,595,000	12.65	16.62
2022	103	9,730,000	4.18	206,760,000	11.39	15.58
2023	112	10,233,000	4.40	195,385,000	10.77	15.17
2024	122	10,782,000	4.64	188,855,000	10.41	15.04
2025	132	11,387,000	4.90	186,222,000	10.26	15.16
2026	141	12,041,000	5.18	188,152,000	10.37	15.54
2027	151	12,740,000	5.48	193,566,000	10.67	16.14
2028	161	13,467,000	5.79	202,011,000	11.13	16.92
2029	171	14,242,000	6.12	212,635,000	11.72	17.84
2030	174	14,807,000	6.37	223,738,000	12.33	18.69
2031	188	15,695,000	6.75	237,464,000	13.08	19.83
2032	198	16,546,000	7.11	252,303,000	13.90	21.02
2033	207	17,417,000	7.49	267,864,000	14.76	22.25
2034	217	18,322,000	7.88	284,506,000	15.68	23.55
2035	227	19,239,000	8.27	301,677,000	16.62	24.90
2036	236	20,164,000	8.67	320,048,000	17.63	26.31
2037	246	21,058,000	9.05	338,412,000	18.65	27.70
Total	**3,101**	**271,553,000**	**116.77**	**4,983,369,000**	**274.58**	**391.35**
Ave.	**155**	**13,577,650**	**5.84**	**249,168,450**	**13.73**	**19.57**

Source: EMPSi Staff calculations, based on RFD oil and gas production numbers

Bbl = barrels, mcf = thousand cubic feet, MMt = million metric tons

Emissions from oil combustion based on an emission factor of 0.43 metric tons CO_2 per barrel; gas combustion based on an emission factor of 0.0551 metric tons CO_2 per mcf (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)

ATTACHMENT A

Mancos Shale Gas Well
Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from the BLM inputs provided for the Mancos Shale.
Note: Green highlights indicate that inputs were obtained from TRFO shale gas calculator.

Gas Analysis & Venting	Speciated Sales Gas Analysis
Gas Component	Mole Fraction (%)
Methane C1	96.028
Ethane C2	0.270
Nitrogen	0.272
Water	0.000
Carbon Dioxide	3.420
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	0.001
i-Butane i-C4	0.000
n-Butane n-C4	0.000
i-Pentane iC5	0.000
n-Pentane nC5	0.000
Hexanes+ C6+	0.001
Heptanes C7	0.000
Octanes	0.000
Benzene	0.015
Ethylbenzene	0.000
n-Hexane n-C6	0.001
Toluene	0.005
2,2,4-Trimethylpentane	0.000
Xylenes	0.001
Helium	0.000
O2	0.000

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad
Well Pad	Trackhoe	100	1	59	10	4
	Dozer	140	1	59	10	4
	Grader	250	1	59	10	4
Well Pad Access Road	Backhoe	100	1	59	10	4
	Dozer	140	1	59	10	4
	Grader	250	1	59	10	3
Pipeline	Backhoe	100	1	59	0	0
	Dozer	140	1	59	0	0
	Grader	250	1	59	10	3

Construction Site	Equipment Type	2015 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
All Sites	100 HP Construction Equipment	0.34	2.86	3.24	0.39	0.38	0.00	595.17	0.02	0.02
All Sites	140 HP Construction Equipment	0.27	1.11	2.83	0.24	0.23	0.00	536.06	0.02	0.02
All Sites	250 HP Construction Equipment	0.24	0.86	2.63	0.16	0.16	0.00	536.14	0.02	0.02

Source: EPA MOVES2014a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	Average # of Operating Hours/Day	# of Operating Days/activity
Main Deck	1468	4	50	24	24
Generators	150	1	75	24	24

Equipment Type	Tier Level	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Main Deck	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Generators	Tier 2	0.26	3.73	4.68	0.22	0.22	0.11	530	0.004	0.002
Source: EPA Federal Tier Standards [a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.										

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level
Main Deck	600	1	80	24	0.3	2270010010	Tier 2
Auxiliary Pump	500	1	80	24	0.3	2270010010	Tier 2
Generators	400	1	75	24	0.3	2270010010	Tier 2
Main Deck	600	1	50	12	7.0	2270010010	Tier 2
Auxiliary Pump	225	1	80	12	3.0	2270010010	Tier 2
Power Swivel	150	1	75	12	3.0	2270010010	Tier 2
Field Generators for Pumps & Lighting	55	3	75	10	25.0	2270010010	Tier 2

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Main Deck	600	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Auxiliary Pump	500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Generators	400	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Main Deck	600	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Auxiliary Pump	225	0.26	2.61	4.68	0.15	0.15	0.11	523	0.004	0.002
Power Swivel	150	0.26	3.73	4.68	0.22	0.22	0.11	520	0.004	0.002
Field Generators for Pumps & Lighting	55	0.30	3.73	5.31	0.30	0.30	0.11	520	0.005	0.002
Source: EPA Federal Tier Standards [a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.										

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0

Area Disturbed for Gas Wells	Avg. Disturbed Acres per wellpad*	Construction Days
Well Pad	4.90	4.00
Well Pad Access Road and Pipeline Construction	9.00	4.00

**includes frac pond, construction days are a weighted average based on acres disturbed*

Cn_CV_Exh	Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	Heavy Duty Haul Trucks	144	11
	Pickup Trucks	Passenger Truck	144	48
Pipeline Construction	Semi Trucks	Heavy Duty Haul Trucks	144	1
	Pickup Trucks	Passenger Truck	144	15

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	Heavy Duty Haul Trucks	175	21
	Pickup Trucks	Passenger Truck	144	6
Rig Hauling	Semi Trucks	Combination Short-haul Truck	144	2
Well Completion & Testing	Semi Trucks	Combination Short-haul Truck	89	175
	Pickup Trucks	Passenger Truck	144	13

Ops_Well WO	Workovers

Construction Equipment

Activity	Equipment Type	Average Capacity (hp)	# of Operating Hours/Day	No. of Engines	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year
Well Workover	Workover Equipment	600	10	1	3	43	1

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/Year
	Type	Class		
Well Workover	WO Rig	Combination Short-haul Truck	144	1
	Haul Truck	Combination Short-haul Truck	144	1
	Pickup Truck	Passenger Truck	144	3

Blowdowns	Blowdown Venting		
Type	**Control Efficiency (%)**	**Volume of gas vented per blowdown Uncontrolled (MCF)**	**Frequency of Blowdown per well per year**
Blowdown	0%	0.81	3.4

Well completions	Completion Venting
Type	**Total volume of gas during completion (mcf)**
All completions	700

Recompletions	Recompletion Venting		
Type	**Control Efficiency (%)**	**Volume of gas vented per well per recompletion Uncontrolled (MCF)**	**No. of recompletion per well per year**
Recompletion	0%	30	0.5

Misc_Engines_Exh	Miscellaneous Engines				
Construction Site	**Capacity (hp)**	**# of Units per Well**	**Fraction of wells to be served by Miscellaneous engine**	**Avg. Load Factor (%)**	**# of Operating Hours/Well**
Miscellaneous Engines	0	0	0	0	0

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	22	6	0	1
pump seals	20	10	0	0
others	0	0	0	0
connectors	15	15	0	0
flanges	18	11	0	1
open-ended lines	0	0	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	91	118	1

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	2	6
Pressure controller	1	6
Valve controllers	2	6

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Road Maintenance	Pickup Truck	18	35

Produced Water Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	Trips/Year/well
	Type	Class			
Water Hauling	Haul Truck	Combination Short-haul Truck	25	4	4

Compressor_Engines Compressor Engines

Type of Compressors / Pumps	Rate (Hp)	# Units per Well	Annual Compression (Hp)	Operating Hours/Year
Wellhead Compressor Engines	100	0.2	20	8,760
Lateral Compressor Engines	0	0	0	0

Reclamation Well Pad Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Well
Road and Well Pad Reclamation	Pickup Truck	35	416

Others Traffic Other Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Year/well
Fuel Haul Truck	Combination Short-haul Truck	25	7	0.6

Heaters and Flaring Heaters

Wellsite Heaters	Heater Rating (MMBtu/hr)	Annual Hours (hr/yr)	No. of Units per Well
Heaters	0.23	1460	1
Reboilers	0.38	4320	0.007

Ops Dehy Dehydrators

Uncontrolled VOC Emissions (tons/mscf)	Uncontrolled CH4 Emissions (tons/mscf)	Uncontrolled CO2 Emissions (tons/mscf)
2.13E-08	1.55E-05	4.35E-07

ATTACHMENT B

Mancos Shale Oil Well
Calculator Inputs by Source Category

KLEINFELDER
Bright People. Right Solutions.

RAMBOLL ENVIRON

Note: Yellow highlights indicate that inputs were obtained from the BLM inputs provided for the Mancos Shale.
Note: Green highlights indicate that inputs were obtained from TRFO conventional oil calculator.

Gas Analysis & Venting	Speciated Sales Gas Analysis
Gas Component	Mole Fraction (%)
Methane C1	88.972
Ethane C2	5.792
Nitrogen	0.094
Carbon Dioxide	2.528
Propane C3	1.365
i-Butane i-C4	0.370
n-Butane n-C4	0.261
i-Pentane iC5	0.155
n-Pentane nC5	0.102
Hexanes+ C6+	0.146
Heptanes C7	0.093
Octanes	0.065
Benzene	0.027
n-Hexane n-C6	0.146
Toluene	0.019
2,2,4-Trimethylpentane	0.000
Xylenes	0.011
Helium	0.000
O2	0.000

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad
Well Pad	Trackhoe	100	1	59	10	4
	Dozer	140	1	59	10	4
	Grader	250	1	59	10	4
Well Pad Access Road	Backhoe	100	1	59	10	4
	Dozer	140	1	59	10	4
	Grader	250	1	59	10	3
Pipeline	Backhoe	100	1	59	0	0
	Dozer	140	1	59	0	0
	Grader	250	1	59	10	3

Construction Site	Equipment Type	2015 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
All Sites	100 HP Construction Equipment	0.34	2.86	3.24	0.39	0.38	0.00	595.17	0.02	0.02
All Sites	140 HP Construction Equipment	0.27	1.11	2.83	0.24	0.23	0.00	536.06	0.02	0.02
All Sites	250 HP Construction Equipment	0.24	0.86	2.63	0.16	0.16	0.00	536.14	0.02	0.02

Source: EPA MOVES2014a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Area Disturbed for Oil Wells	Avg. Disturbed Acres per wellpad*	Construction Days
Well Pad	4.9	4
Well Pad Access Road and Pipeline Construction	9	4

Drilling

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	Average # of Operating Hours/Day	# of Operating Days/activity
Vertical Drill Rig Engine	1000	1	42	24	4
Horizontal Drill Rig Engine	1000	1	59	24	8
Drill Rig Generator	350	1	42	24	12
Trailers Generator	150	1	42	24	12
Air Compressor	550	1	42	24	4
Air Compressor	550	1	42	24	4
Air Compressor Booster	650	1	42	24	4
Forklift	120	1	42	24	4
Aerial Lift	50	1	42	24	0.5
Frontend loader	150	1	42	24	0.5
Dozer	175	1	42	24	0.3

Equipment Type	Tier Level	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Vertical Drill Rig Engine	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Horizontal Drill Rig Engine	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Drill Rig Generator	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Trailers Generator	Tier 2	0.26	3.73	4.68	0.22	0.22	0.11	530	0.004	0.002
Air Compressor	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Air Compressor	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Air Compressor Booster	Tier 2	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002
Forklift	Tier 2	0.26	3.73	4.68	0.22	0.22	0.11	530	0.004	0.002
Aerial Lift	Tier 2	0.30	3.73	5.31	0.30	0.30	0.11	530	0.005	0.002
Frontend loader	Tier 2	0.26	3.73	4.68	0.22	0.22	0.11	530	0.004	0.002
Dozer	Tier 2	0.26	2.61	4.68	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Frac Pump	1500	1	59	24	3	2270010010	Tier 2
Blenders	500	1	42	1	3	2270010010	Tier 2
Auxilary Pump	200	1	42	1	3	2270010010	Tier 2
Sand King	100	1	42	3	3	2270010010	Tier 2
Sand King	100	1	42	3	3	2270010010	Tier 2
Generator	150	1	42	24	3	2270010010	Tier 2

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Frac Pump	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Blenders	500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Auxilary Pump	200	0.26	2.61	4.68	0.15	0.15	0.11	523	0.004	0.002
Sand King	100	0.30	3.73	5.31	0.30	0.30	0.11	520	0.005	0.002
Sand King	100	0.30	3.73	5.31	0.30	0.30	0.11	520	0.005	0.002
Generator	150	0.26	3.73	4.68	0.22	0.22	0.11	520	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0

Cn_CV_Exh	Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	Heavy Duty Haul Trucks	40.0	15.0
	Pickup Trucks	Passenger Truck	40.0	32.0
Pipeline Construction	Semi Trucks	Heavy Duty Haul Trucks	40.0	6.0
	Pickup Trucks	Passenger Truck	40.0	0.0

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	Heavy Duty Haul Trucks	40	24
	Pickup Trucks	Passenger Truck	40	52
Conductor Set Traffic	Semi Trucks	Combination Short-haul Truck	40	1
	Pickup Trucks	Passenger Truck	40	5
Well Completion & Testing	Semi Trucks	Combination Short-haul Truck	40	32
	Pickup Trucks	Passenger Truck	40	60

Ops_Well WO	Workovers

Construction Equipment

Activity	Equipment Type	Average Capacity (hp)	# of Operating Hours/Day	No. of Engines	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year
Well Workover	Workover Equipment	504	9	3	2	42	1

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	300-600	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	Combination Short-haul Truck	0.0	0.0
	Haul Truck	Combination Short-haul Truck	40.0	6.0
	Pickup Truck	Passenger Truck	40.0	6.0

Blowdowns	Blowdown Venting		
Type	**Control Efficiency (%)**	**Volume of gas vented per blowdown Uncontrolled (MCF)**	**Frequency of Blowdown per well per year**
Blowdown	0%	0.75	3.0

Well completions	Completion Venting
Type	Total volume of gas during completion (mcf)
All completions	1,000

Recompletions	Recompletion Venting		
Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	5	1

Misc_Engines_Exh	Miscellaneous Engines				
Construction Site	Capacity (hp)	# of Units per Well	Fraction of wells to be served by Miscellaneous engine	Avg. Load Factor (%)	# of Operating Hours/Well
Pumpjack Engines	65	1	1.0	54	4368

HP Range	2015 Emission Factors (g/hp-hr)								
	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
75	0.44	4.80	2.80	0.18	0.18	0.00	424.16	0.01	0.001

source: NOx and CO from Subpart JJJJ, remaining pollutants from AP-42 rich burn 4-stroke engine emission rates

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	9	13	0	3
pump seals	0	0	0	0
others	0	0	0	0
connectors	19	19	0	0
flanges	10	30	0	4
open-ended lines	0	0	0	0

Pneumatic Pumps

Assumed no pneumatic pumps at oil wels

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	2	6
Pressure controller	1	6
Valve controllers	2	6

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Road Maintenance	Combination Short-haul Truck	80	25

Oil Tanks & Traffic	Oil Tanks
Type	***Base Year Assumptions***
Oil	1. All Oil Throughput Sent Tanks
	2. Average Oil Truck Haul-out of 200 bbl/load
Produced Water	3. 50% of produced water hauled by truck.
	4. Average Water Truck Haulout of 130 bbl/load
	5. Based on water production estimates by well type and planning area from the IHS Energy database provided by BLM staff.

Uncontrolled VOC Emission Factors for Oil and Water Tanks

Oil Tank VOC Emission rate	2.7	lb/bbl
Water Tank VOC Emission rate*	0.26	lb/bbl

**CDPHE Oil and Gas Regulation No. 7 Guidance: An Overview of the Regulations. Table 1*

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	3
CH4 Fraction in Flash Gas	%wt	10
VOC Fraction in Flash Gas	%wt	62
VOC Molecular weight in Flash gas	lb/lb-mol	54

Oil Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	2.3
Temperature of Loaded Liquid (ºR)	510
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Oil Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)
	Type	Class		
Produced Oil Hauling	Haul Truck	Combination Short-haul Truck	25	40
Water Hauling	Haul Truck	Combination Short-haul Truck	25	40

Compressor_Engines	Compressor Engines			
Type of Compressors / Pumps	**Rate (Hp)**	**# Units per Well**	**Annual Compression (Hp)**	**Operating Hours/Year**
Wellhead Compressor Engines	0	0	0	0
Lateral Compressor Engines	0	0	0	0

** no compressor engines are expected to be associated with shale oil wells*

Reclamation	Well Pad Reclamation		
Activity	**Vehicle Type**	**Avg. Vehicle Speed (mph)**	**Total Miles Traveled per Well**
Road and Well Pad Reclamation	Pickup Truck	35	416

Others Traffic	Other Traffic			
Activity	**Vehicle Type**	**Avg. Vehicle Speed (mph)**	**Round Trip Distance (miles)**	**# of Round Trips/Year/well**
Operations Traffic	Pickup Truck	35	40	50

Heaters and Flaring	Heaters		
Wellsite Heaters	**Heater Rating (MMBtu/hr)**	**Annual Hours (hr/yr)**	**No. of Units per Well**
Heaters	0.75	4368	1
Reboilers	0.00	0	0

Ops Dehy	Dehydrators
Assumed no dehydrators at oil wells	

Appendix K

List of Areas of Critical Environmental Concern by Type and BLM Resource Use Management Actions

TABLE OF CONTENTS

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TABLE

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations	Full Phrase
ACEC	area of critical environmental concern
BLM	United States, Department of the Interior, Bureau of Land Management
CSU	controlled surface use
NSO	no surface occupancy
RPFO	Rio Puerco Field Office
TL	timing limitation

Appendix K. List of Areas of Critical Environmental Concern by Type and BLM Resource Use Management Actions

Table K-1, below, lists the ACECs by type and BLM fluid mineral leasing management actions. See the 2003 BLM Resource Management Plan (BLM 2003) for more information.

Table K-1
ACECs

ACEC Name	BLM Fluid Mineral Leasing Management Actions
Cultural ACECs	
Adams Canyon ACEC	NSO stipulation
Ah-shi-sle-pah Road ACEC	NSO stipulation OG-A-4
Angel Peak ACEC	NSO stipulation OG-A-4
Ashii Na'a'a' ACEC	NSO stipulation OG-A-4
Bi Yaazh ACEC	NSO stipulation OG-A-4
Blanco Mesa ACEC	NSO stipulation OG-A-4
Blanco Star Panel ACEC	NSO stipulation OG-A-4
Cagle's Site ACEC	NSO stipulation OG-A-4
Canyon View ACEC	NSO stipulation OG-A-4
Cho'li'l ACEC	NSO stipulation OG-A-4
Christmas Tree Ruin ACEC	NSO stipulation OG-A-4
Crow Canyon ACEC (portions identified in 2003 RMP)	NSO stipulation OG-A-4
Deer House ACEC	NSO stipulation OG-A-4
Delgadita/Pueblo Canyons ACEC	NSO stipulation OG-A-4
Devil's Spring Mesa ACEC	NSO stipulation OG-A-4
Dogie Canyon School ACEC	NSO stipulation OG-A-4
Dzil'na'oodlii ACEC	NSO stipulation OG-A-4
East Side Rincon Site ACEC	NSO stipulation OG-A-4
Encierro Canyon ACEC	NSO stipulation OG-A-4
Encinada Mesa-Carrizo Canyon ACEC (portions identified in 2003 RMP)	NSO stipulation OG-A-4
Farmer's Arroyo ACEC	NSO stipulation OG-A-4
Four Ye'I ACEC	NSO stipulation OG-A-4
Frances Mesa ACEC	NSO stipulation OG-A-4
Gonzalez Canyon-Senon S. Vigil Homestead ACEC	NSO stipulation OG-A-4
Gould Pass Camp ACEC	NSO stipulation OG-A-4
Haynes Trading Post ACEC	NSO stipulation OG-A-4
Hummingbird ACEC	NSO stipulation OG-A-4
Hummingbird Canyon ACEC	NSO stipulation OG-A-4
Jacques Chacoan Community ACEC	NSO stipulation OG-A-4
Kachina Mask ACEC	NSO stipulation OG-A-4
Kin Yazhi ACEC	NSO stipulation OG-A-4
Kiva ACEC	NSO stipulation OG-A-4
Largo Canyon Star Ceiling ACEC	NSO stipulation OG-A-4
Margarita Martinez Homestead ACEC	NSO stipulation OG-A-4
Martin Apodaca Homestead ACEC	NSO stipulation OG-A-4

ACEC Name	BLM Fluid Mineral Leasing Management Actions
Martinez Canyon ACEC	NSO stipulation OG-A-4
Moss Trail ACEC	NSO stipulation OG-A-4
North Road ACEC	NSO stipulation OG-A-4
Pointed Butte ACEC	NSO stipulation OG-A-4
Pregnant Basketmaker ACEC	NSO stipulation OG-A-4
Pretty Woman ACEC	NSO stipulation OG-A-4
Prieta Mesa ACEC	NSO stipulation OG-A-4
Rincon Largo District ACEC	NSO stipulation OG-A-4
Rincon Rockshelter ACEC	NSO stipulation OG-A-4
River Tracts ACEC	NSO stipulation OG-A-4
Rock House-Nestor Martin Homestead ACEC	NSO stipulation OG-A-4
Santos Peak ACEC	NSO stipulation OG-A-4
Shield Bearer ACEC	NSO stipulation OG-A-4
Simon Ruin ACEC	NSO stipulation OG-A-4
Star Rock ACEC	NSO stipulation OG-A-4
Star Spring-Jesus Canyon ACEC	NSO stipulation OG-A-4
Superior Mesa ACEC (portions identified in 2003 RMP)	NSO stipulation OG-A-4
Tapacito and Split Rock ACEC	NSO stipulation OG-A-4
Truby's Tower ACEC	NSO stipulation OG-A-4
Bis sa'ani ACEC	Closed
Chacra Mesa Complex ACEC	Closed
Halfway House ACEC	Closed
The Hogback ACEC	Closed
Holmes Group ACEC	Closed
Morris 41 ACEC	Closed
Pierre's Site ACEC	Closed
Simon Canyon ACEC	Closed
Twin Angels ACEC	Closed
Upper Kin Klizhin ACEC	Closed
Anasazi Communities (Non-Chacoan)	
Cedar Hill ACEC	CSU
La Jara ACEC	CSU
Early Navajo Defensive Sites and Communities	
Crow Canyon ACEC	CSU
Encinada Mesa-Carrizo Canyon ACEC	CSU
Munoz Canyon ACEC	CSU
San Rafael Canyon ACEC	CSU
Superior Mesa ACEC	CSU
Wildlife ACECs	
Mexican Spotted Owl ACEC	CSU-4
Bald Eagle ACEC	TL- November 1 to March 31
Paleontological ACECs	
Torrejon Fossil Fauna ACEC West (the eastern portion of this ACEC is in the Rio Puerco Field Office [RPFO])	CSU (F-9)

Appendix L

Acronyms and Abbreviations

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Appendix L. Acronyms and Abbreviations

AAQS	ambient air quality standards
ACEC	area of critical environmental concern
ACHP	Advisory Council on Historic Preservation
Af	acre-feet
afy	acre-feet per year
AIRFA	American Indian Religious Freedom Act
APD	application for permit to drill
APE	area of potential effect
AQRV	air quality related values
ARPA	Archaeological Resources Protection Act
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	all-terrain vehicle
AUM	animal unit month
BIA	United States Department of the Interior, Bureau of Indian Affairs
BLM	United States Department of the Interior, Bureau of Land Management
BMP	best management practice
BOR	United States Department of the Interior, Bureau of Reclamation
BTU	British thermal unit
CARMMS	Colorado Air Resources Management Modeling Study
CASTNET	Clean Air Status and Trends Network
CBM	coal bed methane
CCNHP	Chaco Culture National Historical Park
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIMPP	culturally important property
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COA	condition of approval
CSU	controlled surface use
CWA	Clean Water Act
dBA	a-weighted decibel
DECRM	Division of Environmental and Cultural Resources Management
DOE	United States Department of Energy
DOI	United States Department of the Interior
EIS	environmental impact statement
EO	executive order
EPA	United States Environmental Protection Agency
ERMA	extensive recreation management area
ESA	Endangered Species Act of 1973
ESD	ecological site description
FAR	functional-at risk

FFO	Farmington Field Office
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FIMO	Federal Indian Minerals Office
FLPMA	Federal Land Policy and Management Act of 1976
FMG	Farmington Mancos-Gallup
Forest Service	United States Department of Agriculture, Forest Service
FRCC	fire regime condition class
GHG	greenhouse gas
GIS	geographical information system
GMU	game management unit
HA	herd area
HAP	hazardous air pollutant
HCPC	historic climax plant community
HMA	herd management area
HPD	Historic Preservation Division
HUC	hydrologic unit code
IMPROVE	Interagency Monitoring of Protected Visual Environments
IPA	Important Plant Area
IPCC	Intergovernmental Panel on Climate Change
ISOP	interagency standard operating procedure
ITA	Indian trust asset
Leq	equivalent continuous 24-hour period
LUA	land use authorization
m/s	meters per second
mcf	thousand cubic feet
MDP	master development plan
MLA	Mineral Leasing Act
MOA	memorandum of agreement
MOU	memorandum of understanding
MSO	Mexican spotted owl
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NAGPRA	Native American Graves Protection and Repatriation Act
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act of 1966 (54 USC 300101)
NHT	National Historic Trail
NIIP	Navajo Indian Irrigation Project
NMBGMR	New Mexico Bureau of Geology and Mineral Resources
NMCRIS	New Mexico Cultural Resource Inventory System
NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environment Department
NMWA	New Mexico Wilderness Alliance
NNDFW	Navajo Nation Department of Fish and Wildlife
NNDPS	Navajo Nation Division of Public Safety

NNEPA	Navajo Nation Environmental Protection Agency
NNRHP	Navajo Nation Registrar of Historic Places
NNWCA	Navajo Nation Water Code Administration
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPS	United States Department of the Interior, National Park Service
NRCS	US Department of Agriculture, Natural Resources Conservation Service
NRHP	National Register of Historic Places
NRO	Navajo Regional Office
NSA	noise-sensitive area
NSO	no surface occupancy
NTL	notice to lessee
OHV	off-highway vehicle
OSHA	Occupational Safety and Health Administration
PCA	plant conservation area
PEIS	preliminary environmental impact statement
PFC	proper functioning condition
PFYC	potential fossil yield classification
PIF	Partners in Flight
PSD	prevention of significant deterioration
RCP	Biological Resource Land Use Clearance Policies and Procedures
RCRA	Resource Conservation and Recovery Act
REA	rapid ecoregional assessment (climate model)
RFD	reasonably foreseeable development
RMP	resource management plan
RMPA	resource management plan amendment
RNA	research natural area
ROD	Record of Decision
ROW	right-of-way
RPFO	Rio Puerco Field Office
SDA	specially designated area
SEZ	solar energy zone
SHPO	State Historic Preservation Officer
SIL	significant impact level
SOP	standard operating procedure
SRMA	special recreation management area
SUYL	sheep units year-long
SWReGAP	Southwest Regional Gap Analysis Program
TCP	traditional cultural property
THPO	Tribal Historic Preservation Officer
TL	timing limitation
US	United States
USACE	US Army Corps of Engineers
USC	United States Code

USDA	US Department of Agriculture
USFWS	United States Department of the Interior, Fish and Wildlife Service
VCC	vegetation condition class
VOC	volatile organic compound
VRI	visual resource inventory
VRM	visual resource management
WFDSS	wildland fire decision support system
WQCC	Water Quality Control Commission
WRCC	Western Regional Climate Center
WSA	wilderness study area
WSD	BLM New Mexico State Office Water Support Document

Appendix M
Glossary

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Appendix M. Glossary

Active floodplain. The portion of the floodplain that contains water during flooding events.

Actual use. The amount of animal unit months consumed by livestock based on the numbers of livestock and grazing dates submitted by the livestock operator and confirmed by the BLM during periodic field checks.

Adaptive management. A type of natural resource management in which decisions are made as part of an ongoing science-based process. Adaptive management involves testing, monitoring, and evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings and the needs of society. Results are used to modify management policy, strategies, and practices.

Air basin. A land area with generally similar meteorological and geographic conditions throughout. To the extent possible, air basin boundaries are defined along political boundary lines and include both the source and receptor areas.

Air pollution. The addition to the atmosphere of any material that may have a deleterious effect on life on our planet.

Allotment. An area of land in which one or more livestock operators graze their livestock. Allotments generally consist of BLM-managed lands but may include other federally managed, state-owned, and private lands. An allotment may include one or more separate pastures. Livestock numbers and periods of use are specified for each allotment.

Alluvial soil. A soil developing from recently deposited alluvium and exhibiting essentially no horizon development or modification of the recently deposited materials.

Alluvium. Clay, silt, sand, gravel, or other rock materials transported by moving water. Deposited in comparatively recent geologic time as sorted or semi-sorted sediment in rivers, floodplains, lakes, and shores, and in fans at the base of mountain slopes.

Ambient air quality. The state of the atmosphere at ground level as defined by the range of measured or predicted ambient concentrations of all significant pollutants for all averaging periods of interest.

Amendment. The process for considering or making changes in the terms, conditions, and decisions of approved resource management plans or management framework plans. Usually only one or two issues are considered, and they involve only a portion of the planning area.

Animal unit month (AUM). The amount of forage necessary for the sustenance of one cow or its equivalent for a period of one month.

Anthropogenic disturbances. Those caused by human actions. Examples are paved highways, graded gravel roads, transmission lines, substations, wind turbines, oil and gas wells, geothermal wells and associated facilities, pipelines, landfills, agricultural conversion, homes, and mines.

Aquatic. Living or growing in or on the water.

Area of critical environmental concern (ACEC). Special area designation established through the BLM's land use planning process (43 CFR 1610.7-2) where special management attention is required (when such areas are developed or used or where no development is required) to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect life and safety from natural hazards. The level of allowable use within an ACEC is established through the collaborative planning process. Designation of an ACEC allows for resource use limitations to protect identified resources or values.

Atmospheric deposition. Air pollution produced when acid chemicals are incorporated into rain, snow, fog, or mist and fall to the earth. Sometimes referred to as acid rain, it comes from sulfur oxides and nitrogen oxides, which are products of burning coal and other fuels, and from certain industrial processes. If the acid chemicals in the air are blown into the area where the weather is wet, the acids can fall to earth in the rain, snow, fog, or mist. In areas where the weather is dry, the acid chemicals may become incorporated into dust or smoke.

Attainment area. A geographic area in which levels of a criteria air pollutant meet the health-based National Ambient Air Quality Standard for that specific pollutant.

Authorized/authorized use. This is an activity (i.e., resource use) occurring on the public lands that is either explicitly or implicitly recognized and legalized by law or regulation. This term may refer to those activities occurring on the public lands for which the BLM, Forest Service, or other appropriate authority (e.g., Congress for RS 2477 rights-of-way or Federal Energy Regulatory Commission for major, interstate rights-of-way) has issued a formal authorization document (e.g., livestock grazing lease/permit, right-of-way grant, coal lease, and oil and gas permit to drill). Formally authorized uses typically involve some type of commercial activity, facility placement, or event. These formally authorized uses are often spatially or temporally limited. Unless constrained or bounded by statute, regulation, or an approved land use plan decision, legal activities involving public enjoyment and use of the public lands (e.g., hiking, camping, and hunting) require no formal BLM or Forest Service authorization.

Avoidance/avoidance area. An area designated through resource management planning for which use for a right-of-way should be avoided if at all possible. Special stipulations may be required if the right-of-way use is unavoidable.

Baseline. The preexisting condition of a defined area or resource that can be quantified by appropriate metrics. During environmental reviews, the baseline is considered the affected environment that exists at the time of the reviews initiation and is used to compare predictions of the effects of the proposed action or a reasonable range of alternatives.

Best management practices (BMPs). A suite of techniques that guide or may be applied to management actions to aide in achieving desired outcomes. BMPs are often developed in conjunction with land use plans, but they are not considered a planning decision unless the plans specify they are mandatory.

Big game. Indigenous, ungulate (hoofed) wildlife species that are hunted, such as elk, deer, bison, bighorn sheep, and pronghorn antelope.

Biodiversity (biological diversity). The variety of life and its processes, and the interrelationships within and among various levels of ecological organization. Conservation, protection, and restoration of biological species and genetic diversity are needed to sustain the health of existing biological systems. Federal resource management agencies must examine the implications of management actions and development decisions on regional and local biodiversity.

Biological soil crust. A complex association between soil particles and cyanobacteria, algae, microfungi, lichens, and bryophytes that live within or atop the uppermost millimeters of soil.

BLM sensitive species. Those species that are not federally listed as endangered, threatened, or proposed under the Endangered Species Act, but that the BLM State Director designates under 16 USC 1536(a)(2) for special management consideration. By national policy, federally listed candidate species are automatically included as sensitive species. Sensitive species are managed so they will not need to be listed as proposed, threatened, or endangered under the Endangered Species Act.

Candidate species. Taxa for which the US Fish and Wildlife Service has sufficient information on their status and threats to propose the species for listing as endangered or threatened under the Endangered Species Act, but for which issuing a proposed rule is currently prevented by higher priority listing actions. Separate lists for plants, vertebrate animals, and invertebrate animals are published periodically in the *Federal Register* (BLM 2008).[1]

Carrying capacity. Describes the number of grazing animals a management unit is able to support without depleting rangeland vegetation or soil resources.

Casual use. Activities ordinarily resulting in no or negligible disturbance of the public lands, resources, or improvements. For examples for rights-of-way casual uses, see 43 CFR 2801.5. For examples for locatable minerals casual uses, see 43 CFR 3809.5.

Categorical exclusion. A category of actions (identified in agency guidance) that do not individually or cumulatively have a significant effect on the human environment, and for which neither an environmental assessment nor an environmental impact statement is required (40 CFR 1508.4); but, a limited form of NEPA analysis is performed.

Chacoan outlier. Large structural complexes with plazas and kivas like the Great Houses of Chaco Canyon, but they are located in other areas of the San Juan Basin. How these outliers functioned in the overall Chacoan system is unclear; however, researchers have suggested these complexes were ceremonial sites for agricultural communities in the Chaco system or even trading posts. Some of these outliers are connected to Chaco Canyon by a series of Chacoan roads that extend for miles straight across the San Juan Basin. Chacoan outliers include, but are not limited to, those listed in Section 502 of PL 96-550. This legislation, which enabled the CCNHP, defines 33 Chaco Culture Archeological Protection Sites, including Allentown, Andrews Ranch, Bee Burrow, Bisa'ani, Casa del Rio, Coolidge, Dalton Pass, Great Bend, Greenlee Ruin, Grey Hill Spring, Halfway House, Haystack, Hogback, Indian Creek, Jacques, Kin Nizhoni, Lake Valley, Las Ventanas, Morris, Muddy Water, Newcomb, Peach Springs, Pierre's Site, Raton Well, San Mateo, Sanostee, Section 8, Skunk Springs/Crumbled House, Squaw Springs, Standing Rock, Twin Angels, Toh-la-kai, and Upper Kin Klizhin.

Checkerboard. This term refers to a landownership pattern of alternating sections of federally owned lands with private, Tribal, or state-owned lands for 20 miles on either side of a land grant railroad (e.g., Union Pacific and Northern Pacific). On land status maps, this alternating ownership is either delineated by color-coding or alphabetic code, resulting in a checkerboard visual pattern.

Chemical vegetation treatment. Application of herbicides to control invasive species and noxious weeds and other unwanted vegetation. To meet resource objectives, the preponderance of chemical treatments would be used in areas where cheatgrass or noxious weeds have invaded sagebrush steppe.

Clean Air Act of 1963 (as amended). Federal legislation governing air pollution control.

[1]US Department of the Interior, Bureau of Land Management. 2008. Manual 6840—Special Status Species Management. Rel. 6-125. Washington, DC. December 12, 2008. Internet website: https://www.blm.gov/sites/blm.gov/files/uploads/mediacenter_blmpolicymanual6840.pdf.

Clean Water Act of 1972 (as amended). Federal legislation governing water pollution control.

Climate change. Any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from the following:

- Natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun
- Natural processes within the climate system (e.g., changes in ocean circulation)
- Human activities that change the atmosphere's composition (e.g., driving motor vehicles) and the land surface (e.g., deforestation, reforestation, urbanization, and desertification).

Closed area. Closed area means an area where off-road vehicle (OHV) use is prohibited. Use of off-road vehicles in closed areas may be allowed for certain reasons; however, such use shall be made only with the approval of the authorized officer (43 CFR 8340.0-5 [h]).

Collaboration. A cooperative process in which interested parties, often with widely varied interests, work together to seek solutions with broad support for managing public and other lands. Collaboration may take place with any interested parties, whether or not they are a cooperating agency.

Commercial forest. BIA forest land that is producing or capable of producing crops of marketable forest products and is administratively available for intensive management and sustained production (25 CFR 163.1).

Communication site. Sites that include broadcast types of uses (e.g., television, AM/FM radio, cable television, and broadcast translator) and non-broadcast uses (e.g., commercial or private mobile radio service, cellular telephone, microwave, local exchange network, and passive reflector).

Community waters. Water wells being used by more than five people.

Condition class (fire regimes). Fire regime condition classes are a measure describing the degree of departure from historical fire regimes, possibly resulting in alterations of key ecosystem components, such as species composition, structural stage, stand age, canopy closure, and fuel loadings. One or more of the following activities may have caused this departure: fire suppression, timber harvesting, livestock grazing, introduction and establishment of exotic plant species, or introduced insects or disease.

Conformance. A proposed action should be specifically provided for in the land use plan or, if not specifically mentioned, should be clearly consistent with the goals, objectives, or standards of the approved land use plan.

Conservation strategy. A strategy outlining current activities or threats that are contributing to the decline of a species, along with the actions or strategies needed to reverse or eliminate such a decline or threats. Conservation strategies are generally developed for species of plants and animals designated as BLM sensitive species or that the US Fish and Wildlife Service or National Oceanographic and Atmospheric Administration-Fisheries has determined to be federal candidates under the Endangered Species Act.

Controlled surface use (CSU). A category of moderate constraint stipulations that allows some use and occupancy of public land while protecting identified resources or values and is applicable to fluid mineral leasing and all activities associated with fluid mineral leasing (e.g., truck-mounted drilling and geophysical exploration equipment off designated routes, and construction of wells and pads). CSU areas are open to fluid mineral leasing, but the stipulation allows the BLM to require special operational constraints, or the activity can be shifted more than 200 meters (656 feet) to protect the specified resource or value.

Cooperating agency. Assists the lead federal agency in developing an environmental assessment or environmental impact statement. These can be any agency with jurisdiction by law or special expertise for proposals covered by NEPA (40 CFR 1501.6). Any Tribe or federal, state, or local government jurisdiction with such qualifications may become a cooperating agency by agreement with the lead agency.

Council on Environmental Quality (CEQ). An advisory council to the President, established by the National Environmental Policy Act of 1969. It reviews federal programs to analyze and interpret environmental trends and information.

Criteria pollutant. The US Environmental Protection Agency uses six criteria pollutants as indicators of air quality. It has established for each of them a maximum concentration above which adverse effects on human health may occur. These threshold concentrations are called National Ambient Air Quality Standards. The criteria pollutants are ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead.

Crucial wildlife habitat. The environment essential to plant or animal biodiversity and conservation at the landscape level. Crucial habitats include biological core areas, severe winter range, winter concentration areas, reproduction areas, and movement corridors.

Crucial winter range. That part of the winter range where a high proportion of the species population is located during severe winter conditions.

Cultural resources. Locations of human activity, occupation, or use. Cultural resources include archaeological, historic, or architectural sites, structures, or places with important public and scientific uses, and locations of traditional cultural or religious importance to specified social or cultural groups.

Culturally important property (CIMPP). Culturally important properties are defined for this RMPA/EIS to include a variety of resource types (for example, traditional cultural properties, sacred sites, ceremonial grounds, and areas of traditional cultural practice) that are generally significant because of their importance to living communities, such as Tribes or other groups. They are discussed in greater detail below. Some of the CIMPPs are relevant to both the BLM and BIA on the lands they manage, while other CIMPP definitions are specifically related to BIA-managed Tribal trust lands and Navajo Nation regulations noted below.

The term CIMPP is intended to provide ease of use when referring to the various resources listed below, which may not fall within the definitions of a historic property per the NHPA, but may be considered under other legislation as described in greater detail. This umbrella term removes the need to continuously refer to all the relevant definitions and regulations beyond the NHPA for these types of resources.

CIMPPs include the following (although this list is not meant to exclude appropriate resources not listed below):

- TCPs as defined in National Register Bulletin 38
- Sacred sites as defined in Executive Order 13007 or AIRFA
- TCPs as identified in the Navajo Nation Policy to Protect TCPs
- Loci of traditional cultural practices as defined in the Navajo Nation Guidelines for the Treatment of Historic, Modern and Contemporary Abandoned Sites (e.g., Navajo home sites that have been blessed or sites of ceremonial activity) that may not be older than 50 years, and, as such, would not be considered historic properties, but could be considered under AIRFA
- Jishchaa' (e.g., gravesites, human remains, or funerary items) as defined in the Navajo Nation Policy for the Protection of Jishchaa'

Often these CIMPPs are identified by Tribes or Tribal individuals in the process of working with agency or other personnel (in many cases these are cultural anthropologists) for specific undertakings.

Cumulative effects. The direct and indirect effects of a proposed project alternative's incremental impacts when they are added to other past, present, and reasonably foreseeable actions, regardless of who carries out the action.

Decibels (dB). A measure of sound intensity over the standard threshold of hearing. An A-weighted decibel (dBA) adjusts the measurement to account for the way in which the ear responds to different frequencies of sound, which relates to the pitch of the sound. Measurements in dBA are decibel scale readings that have been adjusted to attempt to take into account the varying sensitivity of the human ear to different frequencies of sound. Another system of adjustment is C-weighting, the dBC scale. Sometimes dBC is used for specifying peak or impact noise levels, such as gunfire. Leq, or equivalent continuous sound level, accompanies these measures and is a reference to fluctuations in sound levels over a period of time.

Decision area. Lands and federal mineral estate within the BLM-managed or BIA-managed planning area.

Deferred use. To set aside, or postpone, a particular resource use or activity on the public lands to a later time. Generally, when this term is used, the period of the deferral is specified. Deferments sometimes follow the sequence time frame of associated serial actions (e.g., Action B will be deferred until Action A is completed).

Designated roads and trails. Specific roads and trails identified by the BLM or other agency where some type of motorized or nonmotorized use is appropriate and allowed, either seasonally or yearlong (BLM 2005a).

Direct impact. Caused by an action or implementation of an alternative; a direct impact takes place at the same time and place.

Directional drilling. A drilling technique whereby a well is deliberately deviated from the vertical in order to reach a particular part of the oil- or gas-bearing reservoir. Directional drilling technology enables the driller to steer the drill stem and bit to a desired bottom hole location. Directional wells initially are drilled straight down to a predetermined depth and then are gradually curved at one or more different points to penetrate one or more given target reservoirs. This specialized drilling usually is accomplished with the use of a fluid-driven downhole motor, which turns the drill bit. Directional drilling also allows multiple production and injection wells to be drilled from a single surface location, such as a gravel pad, thus minimizing cost and the surface impact of oil and gas drilling, production, and transportation facilities. It can be used to reach a target beneath an environmentally sensitive area (ADNR 2009).[2]

Drainage. In the fluid mineral leasing context, drainage refers to the migration, or movement, of hydrocarbons, inert gases (other than helium), or associated resources caused by production from other wells.

Easement. A right afforded a person or agency to make limited use of another's real property for access or other purposes.

Eastern woodland (BIA): Woodland common to the eastern portion of the Navajo Nation with a typical overstory consisting of approximately 56 percent pinyon, 24 percent juniper, 20 percent Gambel oak, and less than 1 percent Ponderosa pine.

[2]Alaska Department of Natural Resources. 2009. Beaufort Sea Areawide Oil and Gas Lease Sale: Final Finding of the Director. November 9, 2009.

Endangered species. Any species that is in danger of extinction throughout all or a significant portion of its range (BLM 2008a). Under the Endangered Species Act in the US, endangered is the more protected of two categories; the other is threatened. As directed by the Endangered Species Act, the US Fish and Wildlife Service determines designation as endangered or threatened.

Endangered Species Act of 1973 (as amended). Designed to protect critically imperiled species from extinction as a consequence of economic growth and development untempered by adequate concern and conservation. The US Fish and Wildlife Service and the National Oceanic and Atmospheric Administration administer the act. Its purpose is to protect species and the ecosystems they depend on (16 USC 1531–1544).

Environmental assessment (EA). A concise public document prepared to provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact. An EA includes a brief discussion of the need for the proposal, alternatives considered, the environmental impact of the proposed action and alternatives, and a list of agencies and individuals consulted.

Environmental impact statement (EIS). A detailed statement prepared by the responsible official in which a major federal action that significantly affects the quality of the human environment is described, alternatives to the proposed action are provided, and effects are analyzed (BLM 2001).[3]

Ephemeral. A stream that flows only in direct response to precipitation and whose channel is at all times above the water table.

Exclusion area. An area identified through resource management planning that is not available for a right-of-way location under any conditions.

Existing routes. The roads, trails, or ways used by motorized vehicles (such as jeeps, all-terrain vehicles, and motorized dirt bikes), mechanized uses (such as mountain bikes, wheelbarrows, and game carts), pedestrians (hikers), and horseback riders. To the best of the BLM's knowledge, they are in existence at the time of the resource management plan/environmental impact statement publication.

Exploration. Active drilling and geophysical operations to determine the presence of the mineral resource or the extent of the reservoir or mineral deposit.

Extensive recreation management area (ERMA). Administrative units that require specific management consideration to address recreation use, demand, or recreation and visitor services program investments. ERMAs are managed to support and sustain the principal recreational activities and the associated qualities and conditions of the ERMA. ERMA management is commensurate and considered in context with the management of other resources and resource uses (BLM 20140.[4]

Federal Land Policy and Management Act of 1976 (FLPMA). Public Law 94-579, October 21, 1976, often referred to as the BLM's Organic Act, which provides most of its legislated authority, direction policy, and basic management guidance.

[3]US Department of the Interior, Bureau of Land Management. 2001. National Management Strategy for Motorized Off-Highway Vehicle Use on Public Lands. Washington, DC. January 19, 2001.
[4]US Department of the Interior, Bureau of Land Management. 2014. Handbook H-8320-1—Planning for Recreation and Visitor Services. Rel. 8-85. Washington, DC. August 22, 2014. Internet website: https://www.blm.gov/sites/blm.gov/files/uploads/Media_Library_BLM_Policy_H-8320-1.pdf .

Federal mineral estate. Subsurface mineral estate owned by the United States and administered by the BLM. It is the mineral estate underlying BLM-managed, privately owned, and state-owned lands.

Fire frequency. A general term referring to the recurrence of fire in a given area over time.

Fire management plan (FMP). A plan that identifies and integrates all wildland fire management and related activities within the context of approved land/resource management plans. It defines a program to manage wildland fires (wildfire and prescribed fire). The plan is supplemented by operational plans including, but not limited to, preparedness plans, preplanned dispatch plans, and prevention plans. FMPs ensure wildland fire management goals and components are coordinated.

Fluid minerals. Oil, gas, coal bed natural gas, and geothermal resources.

Forage. All browse and herbaceous foods available to grazing animals.

Forage base. The amount of vegetation available for wildlife and livestock use.

Forest product (BIA). Includes timber; a timber product, including lumber, lath, crating, ties, bolts, logs, pulpwood, fuelwood, posts, poles and split products; bark; Christmas trees, stays, branches, firewood, berries, mosses, pinyon nuts, roots, acorns, syrups, wild rice, and herbs; other marketable material; and gravel which is extracted from, and utilized on, Indian forest lands (25 CFR Part 163.1).

Forest resources (BIA). All the benefits from Indian forest lands, including forest products, soil productivity, water, fisheries, wildlife, recreation, and aesthetic or other traditional values of Indian forest lands (25 CFR Part 163.1).

Forest trespass (BIA). The act of illegally removing forest products from, or illegally damaging forest products on, forest lands (25 CFR Part 163.1).

Fragile soils. Soils having a shallow depth to bedrock, minimal surface layer of organic material, textures that are more easily detached and eroded, or are on slopes over 35 percent.

Fugitive dust. Significant atmospheric dust arises from the mechanical disturbance of granular material exposed to the air. Dust generated from these open sources is termed fugitive because it is not discharged to the atmosphere in a confined flow stream. Common sources of fugitive dust include unpaved roads, agricultural tilling operations, aggregate storage piles, and heavy construction operations.

General Mining Law of 1872. Provides for claiming and gaining title to locatable minerals on public lands. Also referred to as the General Mining Law or Mining Law.

Geographic information system (GIS). A system of computer hardware, software, data, people, and applications that capture, store, edit, analyze, and display a potentially wide array of geospatial information.

Geophysical exploration. Work to locate deposits of oil and gas resources and to better define the subsurface.

Geothermal leasing/energy. Natural heat from within the Earth captured for production of electric power, space heating, or industrial steam.

Goal. A broad statement of a desired outcome; goals are usually not quantifiable and may not have established time frames for achievement.

Great house. A large or very large masonry complex constructed within Chaco Canyon from around AD 900 to 1200; some complexes have up to 700 rooms. These structural complexes were well planned, included certain features such as large plazas and kivas (ceremonial structures), and were often multiple stories with distinctive core-and-veneer masonry walls. These great houses were critical elements in an overall Chacoan system that eventually extended across the San Juan Basin and included many other communities.

Great North Road. A Chacoan road that stretches from Pueblo Alto, in Chaco Canyon, New Mexico, to Kutz Canyon in the northern portion of the San Juan Basin. Chacoan roads are generally not visible on the ground and have been identified mainly through aerial photography. The Great North Road is one of the best studied Chacoan roads; it includes four parallel roads along some segments, as well as low masonry features thought to be curbs. The Great North Road is also known as the Chaco Great North Road or the North Road. It includes the BLM-designated North Road ACEC, which covers a subset of the overall Great North Road.

Greenhouse gas (GHG). A gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

Groundwater. Water held underground in soil or permeable rock, often feeding springs and wells.

Guidelines. Actions or management practices that may be used to achieve desired outcomes, sometimes expressed as BMPs. Guidelines may be identified during the land use planning process, but they are not considered a land use plan decision unless the plan specifies they are mandatory. Guidelines for grazing administration must conform to 43 CFR 4180.2.

Habitat. An environment that meets a specific set of physical, biological, temporal, or spatial characteristics that satisfy the requirements of a plant or animal species or group of species for part or all of their life cycle.

Hazardous material. A substance, pollutant, or contaminant that, due to its quantity, concentration, or physical or chemical characteristics, poses a potential hazard to human health and safety or to the environment if released into the workplace or the environment.

Historic properties. According to the National Register of Historic Places (NRHP), historic properties are defined as districts, sites, buildings, structures, and objects significant in American history, archaeology, engineering, and culture.

Impact. The effect, influence, alteration, or imprint caused by an action.

Impairment. The degree to which human-made pollutants have degraded a distance of clear visibility.

Implementation decisions. Decisions that take certain actions to implement land use planning; generally appealable to Interior Board of Land Appeals under 43 CFR 4.410.

Implementation plan. An area- or site-specific plan written to implement decisions made in a land use plan. Implementation plans include both activity plans and project plans.

Indian forest land. Indian lands, including commercial and non-commercial timberland and woodland, that are considered chiefly valuable for the production of forest products or to maintain watershed or other land values enhanced by a forest cover, regardless whether a formal inspection and land classification action has been taken (25 USC 3103).

Indian trust assets (ITA). Legal interests in property held in trust by the United States for Indian Tribes or individuals. The Secretary of the Interior, acting as the trustee, holds many assets in trust.

Indicators. Factors that describe resource conditions and changes and can help the BLM determine trends over time.

Indirect impact. Result from implementing an action or alternative but usually occurs later in time or is removed in distance and is reasonably certain to occur.

Individual Indian allotment. Allotments are parcels of land held in trust by the United States for individual Indians or held by Indians and otherwise subject to a restriction on alienation. That is, there would be a restriction on the Indian owner's ability to sell or transfer the allotment to another party.

Intermittent stream. A stream that flows only at certain times of the year when it receives water from springs or from some surface sources, such as melting snow in mountainous areas. During the dry season and throughout minor drought periods, these streams will not exhibit flow. Geomorphological characteristics are not well defined and are often inconspicuous. In the absence of external limiting factors, such as pollution and thermal modifications, species are scarce and adapted to the wet and dry conditions of the fluctuating water level.

Juniper woodland (BIA): Woodland where more than 90 percent of the overstory is juniper.

Juniper-pinyon woodland (BIA): Woodland where the overstory is 51 to 89 percent juniper and the pinyon is less than 50 percent.

Land health condition. A classification for land health that includes these categories: meeting land health standard(s) and not meeting land health standard(s).

Land tenure adjustments. Landownership or jurisdictional changes. To improve the manageability of the BLM-managed lands and their usefulness to the public, the BLM has numerous authorities for repositioning lands into a more consolidated pattern, disposing of lands, and entering into cooperative management agreements. These land pattern improvements are completed primarily through the use of land exchanges but also through land sales, jurisdictional transfers to other agencies, and the use of cooperative management agreements and leases.

Land use allocation. The identification in a land use plan of the activities and foreseeable development that are allowed, restricted, or excluded for all or part of the planning area, based on desired future conditions (BLM 2005).[5]

Land use plan. A set of decisions that establish management direction for land within an administrative area, as prescribed under the planning provisions of the Federal Land Policy and Management Act; an assimilation of land use plan-level decisions developed through the planning process outlined in 43 CFR 1600, regardless of the scale at which the decisions were developed. The term includes both resource management plans and management framework plans (BLM 2005).[6]

Land use plan decision. Establishes desired outcomes and actions needed to achieve them. Decisions are reached using the planning process in 43 CFR 1600. When they are presented to the public as proposed decisions, they can be protested to the BLM Director. They are not appealable to the Interior Board of Land Appeals.

[5]US Department of the Interior, Bureau of Land Management. 2005. Handbook H-1601-1—Land Use Planning Handbook. Rel. 1-1693. Washington, DC. March 11, 2005. Internet website: https://www.ntc.blm.gov/krc/uploads/360/4_BLM%20Planning%20Handbook%20H-1601-1.pdf.
[6]Ibid.

LANDFIRE VCC. A landscape-scale fire, ecosystem, and fuel assessment mapping project designed to generate comprehensive maps of vegetation, fire, and fuel characteristics nationally and to identify and develop a set of tools to create and distribute data to users.

Leasable minerals. Those minerals or materials designated as leasable under the Mineral Leasing Act of 1920. These include energy-related mineral resources, such as oil, natural gas, coal, and geothermal, and some nonenergy minerals, such as phosphate, sodium, potassium, and sulfur. Geothermal resources are also leasable under the Geothermal Steam Act of 1970.

Lease. Section 302 of the Federal Land Policy and Management Act of 1976 provides the BLM with the authority to issue leases for the use, occupancy, and development of public lands. The BLM issues leases for such purposes as commercial filming, advertising displays, commercial or noncommercial croplands, apiaries, livestock holding or feeding areas not related to grazing permits and leases, native or introduced species harvesting, temporary or permanent facilities for commercial purposes (does not include mining claims), residential occupancy, ski resorts, construction equipment storage sites, assembly yards, oil rig stacking sites, mining claim occupancy (if the residential structures are not incidental to the mining operation), and water pipelines and well pumps related to irrigation and non-irrigation facilities. The regulations establishing procedures for processing these leases and permits are found in 43 CFR 2920.

Lease stipulation. A modification of the terms and conditions on a standard lease form at the time of the lease sale.

Lentic. Pertaining to standing water, such as lakes and ponds.

Limited area. Means an area restricted at certain times, in certain areas, and/or to certain vehicular use. These restrictions may be of any type, but can generally be accommodated within the following type of categories: numbers of vehicles, types of vehicles, time or season of vehicle use, permitted or licensed use only, use on existing roads and trails, and use on designated roads and trails (43 CFR 8340.0-5 [g]).

Locatable minerals. Minerals subject to exploration, development, and sale, exchange, or conveyance by staking mining claims as authorized by the Mining Law of 1872, as amended. These include deposits of gold, silver, and other uncommon minerals not subject to lease or sale.

Loci of traditional cultural practices. Defined in the Navajo Nation Guidelines for the Treatment of Historic, Modern and Contemporary Abandoned Sites as abandoned cultural sites of recent historic, modern, or contemporary age [that] are frequently encountered during cultural resource inventories. Examples could include Navajo home sites, which are the location of a variety of ceremonies and related practices that are “sacred.” Hogans and sweathouses are usually blessed, and sites of ceremonial activity, such as Enemy-way and other religious observances, are also examples. Some of these loci may not be NRHP-eligible but are still considered in their significance under AIRFA. Reasonable attempts should be made to locate and interview former users or knowledgeable local residents about the locus’s significance and any potential methods to avoid or minimize impacts.

Long-term effect. The effect could occur for an extended period after implementation of the alternative. The effect could last several years or more.

Lotic. Pertaining to moving water, such as streams or rivers.

Management decision. A decision the BLM makes to manage public lands. Management decisions include both land use plan decisions and implementation decisions.

Master development plans. A set of information common to multiple planned wells, including drilling plans, surface use plans of operations, and plans for future production.

Mineral. Any naturally formed inorganic material, solid or fluid inorganic substance that can be extracted from the earth, or any of various naturally occurring homogeneous substances (such as stone, coal, salt, sulfur, sand, petroleum, water, or natural gas) obtained usually from the ground. Under federal laws, minerals are considered as locatable (subject to the general mining laws), leasable (subject to the Mineral Leasing Act of 1920), and salable (subject to the Materials Act of 1947).

Mineral entry. The filing of a claim on public land to obtain the right to any locatable minerals it may contain.

Mineral estate. The ownership of minerals, including rights necessary for access, exploration, development, mining, ore dressing, and transportation operations.

Mineral materials. Common varieties of mineral materials, such as soil, sand and gravel, stone, pumice, pumicite, and clay, that are not obtainable under the mining or leasing laws but that can be acquired under the Materials Act of 1947, as amended.

Mining claim. A parcel of land that a miner takes and holds for mining purposes, having acquired the right of possession by complying with the Mining Law and local laws and rules. A mining claim may contain as many adjoining locations as the locator may make or buy. There are four categories of mining claims: lode, placer, mill site, and tunnel site.

Mining Law of 1872. Provides for claiming and gaining title to locatable minerals on public lands. Also referred to as the General Mining Law or Mining Law.

Mitigation. Specific means, measures, or practices that could reduce, avoid, or eliminate adverse impacts. Mitigation can include avoiding the impact altogether by not taking a certain action or parts of an action; minimizing the impact by limiting the degree of magnitude of the action and its implementation; rectifying the impact by repairing, rehabilitating, or restoring the affected environment; reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and compensating for the impact by replacing or providing substitute resources or environments.

Modification. A change to the provisions of a lease stipulation, either temporarily or for the term of the lease. Depending on the specific modification, the stipulation may or may not apply to all sites within the leasehold to which the restrictive criteria are applied.

Monitoring (plan monitoring). The process of tracking the implementation of land use plan decisions and collecting and assessing data necessary to evaluate the effectiveness of land use planning decisions.

Motorized travel. Moving by means of vehicles that are propelled by motors, such as cars, trucks, off-highway vehicles, motorcycles, snowmobiles, aircraft, and boats.

Motorized vehicles or uses. Vehicles that are motorized, such as jeeps, all-terrain vehicles (e.g., four-wheelers and three-wheelers), trail motorcycles or dirt bikes, and aircraft.

Multiple use. According to 43 USC 1702, multiple use is "the management of the public lands and their various resource values so that they are used in the combination that will best meet the present and future needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to changing needs and conditions; the use of some land for less than all of the resources; a combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and nonrenewable resources, including recreation, range, timber, minerals, watershed, wildlife and fish, and natural scenic, scientific and historical values; and harmonious and coordinated management of the various resources without permanent impairment of the productivity of the land and the quality of the environment with consideration being given to the relative values of the resources and not necessarily to the combination of uses that will give the greatest economic return or the greatest unit output" (Federal Land Policy and Management Act; BLM 2008).[7]

Municipal watershed. A watershed area that provides water for use by a municipality as defined by the community and accepted by the state.

National Environmental Policy Act of 1969 (NEPA). Public Law 91-190. Establishes environmental policy for the nation. Among other items, NEPA requires federal agencies to consider environmental values in decision-making processes.

National Historic Trail (NHT). A congressionally designated trail that is an extended, long-distance trail, not necessarily managed as continuous, that follows as closely as possible and practicable the original trails or routes of travel of national historic significance. The purpose of a NHT is the identification and protection of the historic route and the historic remnants and artifacts for public use and enjoyment. A NHT is managed in a manner to protect the nationally significant resources, qualities, values, and associated settings of the areas that such trails may pass through, including the primary use or uses of the trail (BLM 2012).[8]

Native vegetation. Plant species that were found prior to Euro-American settlement; consequently, they are in balance with the ecosystems in which they are found because they have well-developed parasites, predators, and pollinators.

Natural. The Wilderness Act states that wilderness is "protected and managed so as to preserve its natural conditions." In short, wilderness ecological systems should be as free as possible from the effects of modern civilization. Management must foster a natural distribution of native wildlife, fish, and plants by ensuring that ecosystems and ecological processes continue to function naturally. Watersheds, water bodies, water quality, and soils are maintained in a natural condition; associated ecological processes previously altered by human influences will be allowed to return to their natural condition. Fire, insects, and diseases are allowed to play their natural role in the wilderness ecosystem except where these activities threaten human life, property, or high-value resources on adjacent non-wilderness lands. Additional guidance on this is provided in Section 1.6.C of BLM Manual 6340—Management of Designated Wilderness Areas,[9] which addresses the management of specific activities in wilderness. Intended or unintended effects of human activities on the ecological systems inside the wilderness may affect this quality.

Natural processes. Fire, drought, insect and disease outbreaks, flooding, and other events that existed prior to Euro-American settlement and that shaped vegetation composition and structure.

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[7] US Department of the Interior, Bureau of Land Management. 2008. Manual 6840—Special Status Species Management. Rel. 6-125. Washington, DC. December 12, 2008. Internet website: https://www.blm.gov/sites/blm.gov/files/uploads/mediacenter_blmpolicymanual6840.pdf.

[8] US Department of the Interior, Bureau of Land Management. 2012. Manual 6280—Management of National Scenic and Historic Trails and Trails Under Study or Recommended as Suitable for Congressional Designation. Rel. 6-139. Washington, DC. September 14, 2012. Internet website: https://www.blm.gov/style/medialib/blm/wo/Information_Resources_Management/policy/blm_manual.Par.1039.File.dat/M6280%20NSHT%20Management_Final_091212%20(2).pdf.

[9] US Department of the Interior, Bureau of Land Management. 2012. Manual 6340—Management of Designated Wilderness Areas. Rel 6-135. Washington, DC. July 13, 2012. Internet website: https://www.blm.gov/sites/blm.gov/files/uploads/mediacenter_blmpolicymanual6340.pdf.

Navajo forest. All lands covered with ponderosa pine, Douglas fir, aspen, corkbark fir, Colorado blue spruce, or Engelmann spruce in some combination which together comprises a crown closure of greater than seven percent. Meadows and openings within these lands are also considered within the forest (17 NNC 520).

Navajo woodland. All lands covered with oak, pinyon, and/or juniper in some combination which together comprises a crown closure of greater than seven percent. Meadows and openings within these lands are also considered within the forest (17 NNC 520).

Navajo Tribal fee lands. Lands the Navajo Nation owns in fee simple. These lands are not part of the BLM or BIA decision areas because the agencies do not have management authority over them.

Navajo Tribal trust lands. Lands within a Tribe's reservation that the United States holds in trust for the Tribe. Under federal law, such lands generally may not be sold, taxed, or encumbered; however, Tribes may be able to ease trust lands, and the lessee or sublessees of such lands may be able to grant leasehold mortgages on their leasehold interests subject to federal approval.

No surface occupancy (NSO). A major constraint where use or occupancy of the land surface for fluid mineral exploration or development and all activities associated with fluid mineral leasing (e.g., truck-mounted drilling and geophysical exploration equipment off designated routes, and construction of wells and pads) are prohibited to protect identified resource values. Areas identified as NSO are open to fluid mineral leasing, but surface occupancy or surface-disturbing activities associated with fluid mineral leasing cannot be conducted on the surface of the land. Access to fluid mineral deposits would require horizontal drilling from outside the boundaries of the NSO area.

Nonenergy leasable minerals. Those minerals or materials designated as leasable under the Mineral Leasing Act of 1920. Nonenergy minerals include resources such as phosphate, sodium, potassium, and sulfur.

Nonfunctional condition. Riparian-wetland areas that clearly are not providing adequate vegetation, landform, or woody debris to dissipate energies associated with flow events, and thus are not reducing erosion or improving water quality.

Nonmotorized travel. Moving by foot, stock or pack animal, nonmotorized boat, ski, or mechanized vehicle, such as a bicycle.

Noxious weeds. A plant species designated by federal or state law as generally possessing one or more of the following characteristics: aggressive and difficult to manage, parasitic, a carrier or host of serious insects or disease, or nonnative, new, or not common to the United States.

Objective. A description of a desired outcome for a resource. Objectives can be quantified and measured and, where possible, have established time frames for achievement.

Occupancy. Full-time or part-time residence on public lands. It also means activities that involve residence; the construction, presence, or maintenance of temporary or permanent structures that may be used for such purposes; or the use of a watchman or caretaker to monitor activities. Residences or structures include barriers to access, fences, tents, motor homes, trailers, cabins, houses, buildings, and storage of equipment or supplies (43 CFR 3715.0-5).

Off-highway vehicle or off-road vehicle (OHV). Any motorized vehicle capable of, or designated for, travel on or immediately over land, water or other natural terrain. OHV does not include the following:

- Any non-amphibious registered motorboat

- Any military, fire, emergency, or law enforcement vehicle while being used for emergencies
- Any vehicle whose use is expressly authorized by the BLM Authorized Officer or otherwise officially approved
- Vehicles in official use
- Any combat or combat support vehicle when used for national defense emergencies (43 CFR 8340.0-5)

Open. Generally denotes an area is available for a particular use or uses. Refer to specific program definitions found in law, regulations, or policy guidance for application to individual programs. For example, 43 CFR 8340.0-5 defines open as it relates to OHV use.

Ozone. A faint, blue gas produced in the atmosphere from chemical reactions of burning coal, gasoline, and other fuels and chemicals found in such products as solvents, paints, and hairsprays.

Paleontological resources. Any fossilized remains, traces, or imprints of organisms, preserved in the Earth's crust, that are of paleontological interest and that provide information about the history of life on Earth (Paleontological Resources Preservation Act, Section 6301, 16 USC 470aaa-1).

Particulate matter (PM). One of the six criteria pollutants for which the US Environmental Protection Agency established National Ambient Air Quality Standards. Particulate matter is defined as two categories: fine particulate with an aerodynamic diameter of 10 micrometers (PM_{10}) or less, and fine particulate with an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$).

Perennial stream. One that flows continuously. Perennial streams are generally associated with a water table in the localities through which they flow.

Permitted use. The forage allocated by, or under the guidance of, an applicable land use plan for livestock grazing in an allotment under a permit or lease and expressed in animal unit months (43 CFR 4100.0-5).

Permittee. A person or company permitted to graze livestock on public land.

Physiography. The study and classification of the surface features of the Earth.

Pinyon woodland (BIA): Woodland where more than 90 percent of the overstory is pinyon.

Pinyon-juniper woodland (BIA): Woodland where the overstory is 51 to 89 percent pinyon and the juniper is less than 50 percent. **Plan of operations.** Required for all mining activity exploration greater than 5 acres or surface disturbance greater than casual use on certain special category lands. Special category lands are described under 43 CFR 3809.11(c), and include such lands as designated ACECs, lands in the National Wilderness Preservation System, and areas closed to OHVs, among others. In addition, a plan of operations is required for activity greater than casual use on lands patented under the Stock Raising Homestead Act with federal minerals, where the operator does not have the written consent of the surface owner (43 CFR 3814). The plan of operations needs to be filed in the BLM field office with jurisdiction over the land involved. It does not need to be on a particular form but must address the information required by 43 CFR 3809.401(b).

Planning area. The planning area consists of a portion of the FFO and NRO in San Juan, Rio Arriba, McKinley, and Sandoval Counties. It encompasses 4,189,460 acres, including lands managed by the BLM, the BIA (Tribal trust lands and individual Indian allotments), the State of New Mexico, the US Forest Service, the National Park Service, the Bureau of Reclamation, and New Mexico Game and Fish; it also includes private property.

Planning criteria. The standards, rules, and other factors developed by managers and interdisciplinary teams for their use in forming judgments about decision-making, analysis, and data collection during planning. Planning criteria streamlines and simplifies the resource management planning actions.

Planning issues. Concerns, conflicts, and problems with the existing management of public lands. Frequently, issues are based on how land uses affect resources. Some issues are concerned with how land uses can affect other land uses or how the protection of resources affects land uses.

Policy. This is a statement of guiding principles, or procedures, designed and intended to influence BLM planning decisions, operating actions, or other affairs. Policies are established interpretations of legislation, executive orders, regulations, or other presidential, secretarial, or management directives.

Potential wind development area. BLM-managed lands in areas open for wind energy development that exhibit wind speeds of 7 meters (23 feet) per second or greater when measured at 120 meters (394 feet).

Preceramic occupation. Occupation that occurred prior to the use of ceramics, where the most common tools would have been stone or perishable materials. Most researchers identify the initial use of ceramics in the southwestern United States as having occurred sometime around AD 200 during the Basketmaker II period.

Prehistoric. In the southwestern United States, prehistoric refers to the period prior to the entrance of Europeans to the Southwest with the respective 1539 and 1540 journeys of Fray Marcos de Niza and Coronado through Arizona and New Mexico.

Prescribed fire. A wildland fire originating from a planned ignition to meet specific objectives identified in a written, approved, prescribed fire plan for which National Environmental Policy Act requirements (where applicable) have been met before ignition.

Produced water. Water trapped in underground formations that is brought to the surface during oil and gas exploration and production. In traditional oil and gas wells, produced water is brought to the surface along with oil or gas.

Proper functioning condition (PFC). A term describing stream health that is based on the presence of adequate vegetation, landform, and debris to dissipate energy, reduce erosion, and improve water quality.

Protohistoric. In the southwestern United States, protohistoric refers to the early historic period when there was limited contact with Europeans. This period is generally considered to start with Coronado's 1540 entrada and end with Don Juan de Oñate's 1598 arrival with hundreds of Spanish to settle New Mexico.

Public domain. Any or all of those areas of land that the original states ceded to the federal government and other lands that were later acquired by treaty, purchase, or cession and are disposed of only under the authority of Congress.

Public land. Land or interest in land owned by the United States and administered by the Secretary of the Interior through the BLM without regard to how the United States acquired ownership, except lands on the Outer Continental Shelf and lands held for the benefit of Indians, Aleuts, and Eskimos (BLM 2005).[10]

Public lands not designated as recreation management areas. All lands not designated as a SRMA or ERMA.

Range improvement. An authorized physical modification or treatment designed to improve production of forage, change vegetation composition, control patterns of use, provide water, stabilize soil and water conditions, and restore, protect, and improve the condition of rangeland ecosystems to benefit livestock, wild horses and burros, and fish and wildlife. The term includes structures, treatment projects, and use of mechanical devices or modifications achieved through mechanical means (43 CFR 4100.0-5).

Rangeland treatment. All methods of artificial range improvement arid soil stabilization, such as reseeding, brush control (chemical and mechanical), pitting, furrowing, and water spreading.

Raptor. Bird of prey with sharp talons and strongly curved beaks, such as a hawk, owl, falcon, or eagle.

Reasonable foreseeable development (RFD) scenario. The prediction of the type and amount of oil and gas activity that would occur in a given area. The prediction is based on geologic factors, past history of drilling, projected demand for oil and gas, and industry interest.

Reclamation. The suite of actions taken within an area affected by human disturbance, the outcome of which is intended to change the condition of the disturbed area to meet predetermined objectives or make it acceptable for certain defined resources (e.g., wildlife habitat, grazing, and ecosystem function).

Recreation experiences. Psychological outcomes realized (1) by recreation-tourism participants as a direct result of their on-site leisure engagements and recreation-tourism activity participation, (2) by nonparticipating community residents as a result of their interaction with visitors and guests within their community, or (3) by interaction with the BLM and other public and private recreation-tourism providers and their actions.

Recreation management area (RMA). Includes SRMAs and ERMAs; see *SRMA* and *ERMA*.

Recreation management zone (RMZ). A subdivision of a recreation management area that further delineates specific recreation opportunities and recreation setting characteristics (BLM 2014).[11]

Recreation opportunities. Favorable circumstances enabling visitors' engagement in a leisure activity to realize immediate psychological experiences and attain more lasting, value-added, beneficial outcomes.

Recreation settings. The collective distinguishing attributes of landscapes that influence and sometimes actually determine what kinds of recreation opportunities are produced.

Reference state. The state where the functional capacities represented by soil/site stability, hydrologic function, and biotic integrity are performing at an optimum level under the natural disturbance regime. This state usually includes what is often referred to as the potential natural plant community.

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[10]US Department of the Interior, Bureau of Land Management. 2005. Handbook H-1601-1—Land Use Planning Handbook. Rel. 1-1693. Washington, DC. March 11, 2005. Internet website: https://www.ntc.blm.gov/krc/uploads/360/4_BLM%20Planning%20Handbook%20H-1601-1.pdf.

[11]US Department of the Interior, Bureau of Land Management. 2014. Handbook H-8320-1—Planning for Recreation and Visitor Services. Rel. 8-85. Washington, DC. August 22, 2014. Internet website:https://www.blm.gov/sites/blm.gov/files/uploads/Media_Library_BLM_Policy_H-8320-1.pdf .

Rehabilitate/rehabilitation. Returning disturbed lands as near to their pre-disturbed condition as is reasonably practical or as specified in approved permits.

Relict forest community. A community is defined as (1) a species properly belonging to an earlier vegetation than that which is now found; (2) a plant community or species which, through the operation of some compensatory or protective environmental feature, has survived some important change (e.g., climate or land use that has altered the general vegetation in the surrounding area); (3) a remnant or fragment of a flora that remains from some former period when it was more completely developed; (4) a remnant of the population of a species that was formerly more widespread and is unique and/or rare to the present-day vegetation community. Within the FFO, remnant ponderosa pine trees found in badlands represent relict species in the present-day badlands vegetation community.

Renewable energy. Energy resources that constantly renew themselves or that are regarded as practically inexhaustible. These include solar, wind, geothermal, hydro, and biomass. Although particular geothermal formations can be depleted, the natural heat in the Earth is a virtually inexhaustible reserve of potential energy.

Resource management plan (RMP). A land use plan prescribed by the Federal Land Policy and Management Act that establishes, for a given area of land, land use allocations and coordination guidelines for multiple use, objectives, and actions to be achieved.

Restore/restoration. Implementation of passive or active management actions designed to increase or maintain perennial herbaceous species and landscape cover of sagebrush so that plant communities are more resilient to disturbance and invasive species over the long term. The long-term goal is to create functional, high-quality habitat that is occupied by sage-grouse. A short-term goal may be to restore the landform, soils, and hydrology and to increase the percentage of preferred vegetation, seeding of desired species, or treatment of undesired species.

Restriction/restricted use. A limitation or constraint on public land uses and operations. Restrictions can be of any kind, but most commonly apply to certain types of vehicle use, temporal or spatial constraints, or certain authorizations.

Revegetate/revegetation. The process of putting vegetation back in an area where it previously existed, which may or may not simulate natural conditions.

Revision. The process of completely rewriting the land use plan due to changes in the planning area affecting major portions of the plan or the entire plan.

Right-of-way (ROW). Public lands that the BLM authorizes a holder to use or occupy under a grant; examples are roads, pipelines, power lines, and fiber optic lines.

Right-of-way (ROW) avoidance area. An area identified through resource management planning to be avoided but may be available for ROW location with special stipulations.

Right-of-way (ROW) exclusion area. An area identified through resource management planning that is not available for ROW location under any conditions.

Riparian area. A form of wetland transition between permanently saturated wetlands and upland areas. Riparian areas exhibit vegetation or physical characteristics that reflect the influence of permanent surface or subsurface water. Typical riparian areas include lands along, next to, or contiguous with perennially and intermittently flowing rivers and streams, glacial potholes, and the shores of lakes and reservoirs with stable water levels. Excluded are ephemeral streams or washes that lack vegetation and depend on free water in the soil.

Riparian management zone. Areas where riparian values receive primary emphasis with all activities to the extent possible. Maintaining and restoring quality riparian habitat (including vegetation) is important as habitat for many wildlife species, to maintain water quality, appropriate woody material, and nutrient routing to aquatic habitats, and to maintain appropriate stream channel morphology.

Riparian zone. An area one-quarter-mile wide encompassing riparian and adjacent vegetation.

Road. A linear route declared a road by the owner, managed for use by low-clearance vehicles having four or more wheels, and maintained for regular and continuous use.

Rotation. Grazing rotation between pastures in the allotment for the permitted time.

Routes. Multiple roads, trails, and primitive roads; a group or set of roads, trails, and primitive roads that represents less than 100 percent of the BLM transportation system. Generically, components of the transportation system.

Sale (public land). A method of land disposal pursuant to Section 203 of the Federal Land Policy and Management Act, whereby the United States receives a fair-market payment for the transfer of land from federal ownership. Public lands determined suitable for sale are offered on the initiative of the BLM. The RMP must identify the lands. Any lands to be disposed of by sale that are not identified in the current RMP, or that meet the disposal criteria identified in the RMP, require a plan amendment before a sale can occur.

Saturated soils. Occur when the infiltration capacity of the soil is exceeded from above due to rainfall or snowmelt runoff. Soils can also become saturated from groundwater inputs.

Scarification. Shallow loosening of the soil surface.

Scoping process. An early and open public participation process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action.

Season of use. The time during which livestock grazing is permitted on a given range area, as specified in the grazing lease.

Seeding. A vegetation treatment that includes the application of grass, forb, or shrub seed, either by air or from the ground. In areas of gentle terrain, ground applications of seed are often accomplished with a rangeland drill. Seeding allows the establishment of native species or placeholder species and restoration of disturbed areas to a perennial-dominated cover type, thereby decreasing the risk of subsequent invasion by exotic plant species. Seeding would be used primarily as a follow-up treatment in areas where disturbance or the previously described treatments have removed exotic plant species and their residue.

Sensitive soils. Sensitive soils have a high risk of degradation from surface uses, such as the soils poorly suited to reclamation, badlands, soils with severe erosion hazard, soils on steep slopes, and hydric soils. Criteria used to determine soil sensitivity to surface uses are continually adapted as conditions change or new information or technology becomes available.

Short-term effect. Occurs only during or immediately after implementation of an alternative.

Solitude or primitive and unconfined recreation. The Wilderness Act states that wilderness has "outstanding opportunities for solitude or a primitive and unconfined type of recreation." Wilderness provides opportunities for people to experience natural sights and sounds; remote, isolated, unfrequented, or secluded places; and freedom, risk, and the physical and emotional challenges of self-discovery and self-reliance. Any one wilderness does not have to provide all these opportunities, nor is it necessary they be present on every acre of a given wilderness. Where present, however, the preservation of these opportunities is important to the preservation of wilderness character as a whole. Settings that reduce these opportunities, such as visitor encounters, signs of modern civilization, recreation facilities, and management restrictions on visitor behavior, impair this quality.

Special recreation management area (SRMA). An administrative public lands unit identified in land use plans where the existing or proposed recreation opportunities and recreation setting characteristics are recognized for their unique value, importance, or distinctiveness, especially as compared to other areas used for recreation (BLM 2014).[12]

Special recreation permit (SRP). Authorization that allows for recreational uses of public lands and related waters. Issued as a means to control visitor use, protect recreational and natural resources, and provide for the health and safety of visitors. Commercial SRPs are also issued to provide a fair return for the commercial use of public lands.

Special status species. BLM special status species are those listed, candidate, or proposed for listing under the Endangered Species Act. They are also those a BLM State Director designates as BLM sensitive. Such species require special management consideration to promote their conservation and reduce the likelihood and need for future listing under the Endangered Species Act. All federally listed candidate species, proposed species, and delisted species in the 5 years following delisting are conserved as BLM sensitive species.

Split-estate. The circumstance where the surface of a particular parcel is owned by a different party than the minerals underlying the surface. Split-estates may have any combination of surface/subsurface owners: federal/state, federal/private, state/private, Navajo trust/federal, Navajo allotment/federal, or percentage ownerships. When referring to the split-estate ownership on a particular parcel of land, it is generally necessary to describe the surface/subsurface ownership pattern of the parcel.

Stabilize. The process of stopping further damage from occurring.

Standard. A description of the physical and biological conditions or degree of function required for healthy, sustainable lands (e.g., land health standards), expressed as a desired outcome (goal).

Standard lease terms and conditions. Areas may be open to leasing with no specific management decisions defined in an RMP; however, these areas are subject to lease terms and conditions as defined on the lease form (Form 3100-11, Offer to Lease and Lease for Oil and Gas; and Form 3200-24, Offer to Lease and Lease for Geothermal Resources).

State. An integrated soil and vegetation unit having one or more biological communities that occur on a particular ecological site and that are functionally similar with respect to the three attributes (soil/site stability, hydrologic function, and biotic integrity) under natural disturbance regimes.

Steep slopes. Those that are 30 percent or greater.

Stipulation (general). A term or condition in an agreement or contract.

Stipulation (oil and gas). A provision that modifies standard oil and gas lease terms and conditions to protect other resource values or land uses and is attached to and made a part of the lease. Typical lease

[12]US Department of the Interior, Bureau of Land Management. 2014. Handbook H-8320-1—Planning for Recreation and Visitor Services. Rel. 8-85. Washington, DC. August 22, 2014. Internet website: https://www.blm.gov/sites/blm.gov/files/uploads/Media_Library_BLM_Policy_H-8320-1.pdf.

stipulations are no surface occupancy (NSO), timing limitations (TL), and controlled surface use (CSU). Lease stipulations are developed through the RMP process.

Surface disturbance. Surface-disturbing activities result from land uses and affect soils and vegetation to varying degrees depending on the amount, location, and type of disturbance; soil type; time of year; climate; and surface hydrology. Surface-disturbing activities remove protective vegetation cover and soil crusts and can alter soil physical, chemical, and biological properties, increasing soil susceptibility to water and wind erosion and decreasing its quality and site productivity.

Surface-disturbing activities. An action that alters the vegetation, surface/near surface soil resources, or surface geologic features beyond natural site conditions and on a scale that affects other public land values. Examples of surface-disturbing activities are operation of heavy equipment to construct well pads, roads, pits, and reservoirs; installation of pipelines and power lines; and the conduct of several types of vegetation treatments (e.g., prescribed fire). Surface-disturbing activities may be either authorized or prohibited.

Surface use plan of operations. Describes the operators' plans for the surface use, disturbance, and operations and is one of the required components of a "complete APD package," in accordance with 43 CFR 3162.3-1(d)(2) (https://ecfr.io/Title-43/pt43.2.3160#se43.2.3162_13_61).

Surface uses. These are all the various activities that may be present on the surface or near surface (e.g., pipelines) of the public lands. The term does not refer to those subterranean activities (e.g., underground mining) on public lands or federal mineral estate. When administered as a use restriction (e.g., no surface use), this phrase prohibits all but specified resource uses and activities in a certain area to protect particular sensitive resource values and property. This designation typically applies to small acreage sensitive resource sites (e.g., plant community study exclosure) and administrative sites (e.g., government ware-yard) where only authorized agency personnel are admitted.

Sustained yield. The achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the public lands consistent with multiple uses.

Technically/economically feasible. Actions that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the applicant's standpoint. The BLM is solely responsible for determining what actions are technically and economically feasible. The BLM will consider whether implementation of the proposed action is likely given past and current practice and technology; this consideration does not necessarily require a cost-benefit analysis or speculation about an applicant's "costs and profit" (CEQ 1981; BLM 2008).[13, 14]

Temporary route. Temporary routes are defined as short-term overland roads, primitive roads, or trails; they are authorized or acquired for the development, construction, or staging of a project or event that has a finite lifespan.

Temporary use. The opposite of permanent/permanent use. It is a relative term and has to be considered in the context of the resource values affected and the nature of the resource uses and activities

[13]Council on Environmental Quality. 1981. Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations. Washington, DC. March 23, 1981.
[14]US Department of the Interior, Bureau of Land Management. 2008. Handbook H-1790-1—National Environmental Policy Act. Rel. 1-1710. Washington, DC. January 30, 2008. Internet website: https://www.ntc.blm.gov/krc/uploads/366/NEPAHandbook_H-1790_508.pdf.

taking place. Generally, a temporary activity is considered to be one that is not fixed in place and is of short duration.

Terrestrial. Living or growing in or on the land.

Threatened species. Any species that is likely to become endangered in the foreseeable future throughout all or a significant portion of its range (BLM 2008a). Under the Endangered Species Act in the United States, threatened is less protected than endangered. The US Fish and Wildlife Service, as directed by the Endangered Species Act, determines designation as threatened or endangered.

Timber. Standing trees, downed trees, or logs that are capable of being measured in board feet.

Timing limitation (TL). This stipulation, a moderate constraint, is applicable to fluid mineral leasing, all activities associated with fluid mineral leasing (e.g., truck-mounted drilling and geophysical exploration equipment off designated routes, and construction of wells and pads), and other surface-disturbing activities (i.e., those not related to fluid mineral leasing). Areas identified for a TL are closed to fluid mineral exploration and development, surface-disturbing activities, and intensive human activity during identified time frames. This stipulation does not apply to operation and basic maintenance, including associated vehicle travel, unless otherwise specified. Construction, drilling, completions, and other operations considered to be intensive are not allowed. Intensive maintenance, such as workovers on wells, is not permitted. TLs can overlap spatially with no surface occupancy and controlled surface use stipulations, as well as with areas that have no other restrictions.

Total dissolved solids. Salt, or an aggregate of carbonates, bicarbonates, chlorides, sulfates, phosphates, and nitrates of calcium, magnesium, manganese, sodium, potassium, and other cations that form salts.

Total maximum daily load (TMDL). An estimate of the total quantity of pollutants (from all point, nonpoint, and natural sources) that may be allowed into waters without exceeding applicable water quality criteria.

Traditional cultural property (Navajo Nation definition). Most traditional cultural properties (TCPs) significant to Navajos are of the type commonly called "sacred places" (*hodiyin*) as defined in the Navajo Nation Policy to Protect Traditional Cultural Properties. The Navajo Nation's use of TCP is—at least in part—talking about the same kinds of TCPs as described in NPS Bulletin 38. They note, however, that this term offends many Navajo traditional practitioners and instead focus on how what makes a place sacred is its association with aspects of the past that people connect with their present concerns of living.

Navajo TCPs without clear evidence of human use include, but are not limited to, the following types: places for gathering plants for use in ceremonies and other traditional purposes; places for gathering minerals for ceremonial and other traditional uses; places for gathering contents of sacred bundles; places for gathering other materials for ceremonial and other traditional purposes; prayer offering places; places associated with the origin stories of particular ceremonials; places associated with the general Navajo origin story; places associated with the origin of a clan; places associated with the origin of a Navajo custom; places identified as the home of a Holy Being such as Wind, Lightning, Big Snake; a location of echoes (Talking Rocks, which convey human words to the Holy People); natural discoloration of rock that has some kind of supernatural power; places where an apparition or other supernatural event occurred; and places that have played a part in the life cycle rituals of individuals (such as the spot where a newborn baby's umbilical cord is placed). Many of these places are features of the natural landscape, such as mountains, hills, rocky outcrops, springs, and individual trees.

Traditional cultural property (NPS definition). A property that is eligible for inclusion in the National Register of Historic Places (NRHP) based on its associations with the cultural practices, traditions, beliefs, lifeways, arts, crafts, or social institutions of a living community, as defined in NPS Bulletin 38 (Parker and King 1998). TCPs are rooted in a traditional community's history and are important in maintaining the continuing cultural identity of the community. The cultural practices or beliefs that give a TCP its significance are, in many cases, still observed at the time a TCP is considered for inclusion in the NRHP. Because of this, it is sometimes perceived that the practices or beliefs themselves, not the property, make up the TCP. While the beliefs or practices associated with a TCP are of central importance, the NRHP does not include intangible resources. The TCP must be a physical property or place—that is, a district, site, building, structure, or object.

Traditional use. An ongoing and continuing use of the land. Examples include grazing and piñon nut gathering.

Trail. A linear route managed for human-power (e.g., hiking or bicycling), stock (e.g., horseback riding), or off-highway vehicle forms of transportation or for historical or heritage values. Trails are not generally managed for use by four-wheel drive or high-clearance vehicles.

Transition. A shift between two states. Transitions are not reversible by simply altering the intensity or direction of factors that produced the change. Instead, they require new inputs, such as revegetation or shrub removal. Practices such as these that accelerate succession are often expensive to apply.

Transmission. The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points where it is transformed for delivery to consumers or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer.

Transportation system. The sum of the BLM's recognized inventory of linear features (roads, primitive roads, and trails) formally recognized, designated, and approved as part of the BLM's transportation system.

Travel management areas (TMA). Polygons or delineated areas where a rational approach has been taken to classify areas open, closed, or limited, and has identified or designated a network of roads, trails, ways, landing strips, and other routes that provide for public access and travel across the planning area. All designated travel routes within travel management areas should have a clearly identified need and purpose, and clearly defined activity types, modes of travel, and seasons or time frames for allowable access or other limitations (BLM 2005).[15]

Trespass. Any unauthorized use of public land.

Tribal interests. Native American or Native Alaskan economic rights, such as Indian trust assets, resource uses, access guaranteed by treaty rights, and subsistence uses.

Tribal trust land. Lands held in trust by the United States government for the use of a Tribe. The United States holds the legal title, and the Tribe holds the beneficial interest. This is the largest category of Indian land. Tribal trust land is held communally by the Tribe and is managed by the Tribal government.

Understory. That portion of a plant community growing underneath the taller plants on the site.

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[15]US Department of the Interior, Bureau of Land Management. 2005. Handbook H-1601-1—Land Use Planning Handbook. Rel. 1-1693. Washington, DC. March 11, 2005. Internet website: https://www.ntc.blm.gov/krc/uploads/360/4_BLM%20Planning%20Handbook%20H-1601-1.pdf.

Undeveloped. The Wilderness Act states that wilderness is an area "of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation," "where man himself is a visitor who does not remain," and "with the imprint of man's work substantially unnoticeable." Wilderness has minimal evidence of modern human occupation or modification. This quality is impaired by the presence of structures or installations, and by the use of motor vehicles, motorized equipment, or mechanical transport that increase people's ability to occupy or modify the environment. More detail on the activities that impair this quality is found in Section 1.6.B of this policy.

Unique or supplemental values. The Wilderness Act states that wilderness areas "may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value." Though these values are not required of any wilderness, where they are present they are part of that area's wilderness character and must be protected as rigorously as any of the four required qualities. They may include historical, cultural, paleontological, or other resources not necessarily considered a part of any of the other qualities. These values are identified in a number of ways: in the area's designating legislation, through its legislative history, by the original wilderness inventory, in a wilderness management plan, or at some other time after designation.

Unitization. Operation of multiple leases as a single lease under a single operator.

Unitized area. A group of contiguous oil and gas lease holdings where the lessee holds an agreement with the federal government so that exploration, drilling, and production of the resource proceeds in the most efficient and economical manner.

Untrammeled. The Wilderness Act states that wilderness is "an area where the earth and its community of life are untrammeled by man." A "trammel" is literally a net, snare, hobble, or other device that impedes the free movement of an animal. Here, used metaphorically, "untrammeled" refers to wilderness as essentially unhindered and free from modern human control or manipulation. This quality is impaired by human activities or actions that control or manipulate the components or processes of ecological systems inside wilderness.

Utility corridor. Tract of land varying in width and forming a passageway through which various commodities, such as oil, gas, and electricity, are transported.

Valid existing rights. Documented legal rights or interests in the land that allow a person or entity to use said land for a specific purpose and that are still in effect. Such rights include fee title ownership, mineral rights, rights-of-way, easements, permits, and licenses. Such rights may have been reserved, acquired, leased, granted, permitted, or otherwise authorized over time.

Vegetation condition class (VCC). Quantifies the amount that current vegetation has departed from the simulated historical vegetation reference conditions. Three condition classes describe low departure (VCC 1), moderate departure (VCC 2), and high departure (VCC 3). VCC is calculated based on changes to species composition, structural stage, and canopy closure.

Vegetation manipulation. Planned alteration of vegetation communities through the use of mechanical or chemical means, seeding, prescribed fire, or managed fire to achieve desired resource objectives.

Vegetation treatments. Management practices that change the vegetation structure to a different stage of development. Vegetation treatment methods include managed fire, prescribed fire, chemical or mechanical means, and seeding.

Vegetation type. A plant community with immediately distinguishable characteristics based on and named after the apparent dominant plant species.

Visibility (air quality). A measure of the ability to see and identify objects at different distances.

Visitor day. Twelve visitor hours that may be aggregated by one or more persons in single or multiple visits.

Visual resources. The visible physical features on a landscape (topography, water, vegetation, animals, structures, and other features) that comprise the scenery of the area.

Watershed. Topographical region or area delineated by water draining to a particular watercourse or body of water.

Wild and Scenic Study River. Rivers identified for study by Congress under Section 5(a) of the Wild and Scenic Rivers Act or identified for study by the Secretary of Agriculture or the Secretary of the Interior under Section 5(d)(1) of the Wild and Scenic Rivers Act. These rivers are studied under the provisions of Section 4 of the Wild and Scenic Rivers Act (BLM 2012).[16]

> **Eligible river.** A river or river segment found to meet criteria found in Sections 1(b) and 2(b) of the Wild and Scenic Rivers Act of being free flowing and possessing one or more outstandingly remarkable value
>
> **Suitable river.** An eligible river segment found through administrative study to meet the criteria for designation as a component of the National System, as specified in Section 4(a) of the Wild and Scenic Rivers Act

Wildcat well. An exploratory oil well drilled in land not known to be an oil field.

Wilderness. A congressionally designated area of undeveloped federal land retaining its primeval character and influence, without permanent improvements or human habitation, that is protected and managed to preserve its natural conditions and that has the following characteristics:

- Generally, it appears to have been affected mainly by the forces of nature, with human imprints substantially unnoticeable.
- It has outstanding opportunities for solitude or a primitive and unconfined type of recreation.
- It has at least 5,000 acres or is large enough to make practical its preservation and use in an unimpaired condition.
- It may also contain ecological, geological, or other features of scientific, educational, scenic, or historic value.

The definition is contained in Section 2(c) of the Wilderness Act of 1964 (78 Stat. 891).

Wilderness characteristics. Wilderness characteristics attributes are the area's size, its apparent naturalness, and outstanding opportunities for solitude or a primitive and unconfined type of recreation. They may also include supplemental values, such as ecological, geological, or other features of scientific, educational, scenic, or historical value. Lands with wilderness characteristics have been inventoried and determined by the BLM to contain wilderness characteristics, as defined in Section 2(c) of the Wilderness Act, as follows:

[16]US Department of the Interior, Bureau of Land Management. 2012. Manual 6400—Wild and Scenic Rivers – Policy and Program Direction for Identification, Evaluation, Planning, and Management. Rel. 6-136. Washington, DC. July 13, 2012. Internet website: https://www.blm.gov/sites/blm.gov/files/uploads/mediacenter_blmpolicymanual6400.pdf.

- Naturalness—The degree to which an area generally appears to have been affected primarily by the forces of nature with the imprint of people's work substantially unnoticeable
- Opportunity—A situation or condition favorable for attainment of a goal
- Outstanding—1) Standing out among others of its kind, conspicuous, prominent; 2) Superior to others of its kind, distinguished, or excellent
- Primitive and unconfined recreation—Nonmotorized, nonmechanized (except as provided by law), and undeveloped types of recreation
- Solitude—The state of being alone or remote from others, isolation; a lonely or secluded place

Wilderness study area (WSA). A designation made through the land use planning process of a roadless area found to have wilderness characteristics, as described in Section 2(c) of the Wilderness Act of 1964.

Wildland fire. Wildland fire is a general term describing any non-structure fire that occurs in the wildland. Wildland fires are categorized into two distinct types (USDA and DOI 2009):[17]

- Wildfires—Unplanned ignitions or prescribed fires that are declared wildfires
- Prescribed Fires—Planned ignitions

Wildland-urban interface (WUI). The line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetation fuels.

Withdrawal. An action that restricts the use of public land and segregates the land from the operation of some or all of the public land and mineral laws. Withdrawals are also used to transfer jurisdiction of management of public lands to other federal agencies.

Woodland (BIA). BIA forest land not included within the timberland classification, stocked, or capable of being stocked, with tree species of such form and size to produce forest products that are generally marketable within the region for products other than lumber, pulpwood, or veneer (25 CFR 163.1).

Yearling factor. Adjustments made to grazing permits in which yearlings are the class of livestock. Yearlings were rated at 0.75 animal unit months for these permits, allowing more yearlings to be run than cattle.

[17]US Department of Agriculture and US Department of the Interior. 2009. Guidance for Implementation of Federal Wildland Fire Management Policy. Wildland Fire Leadership Council. Internet website: https://www.nifc.gov/policies/policies_documents/GIFWFMP.pdf. February 2009.

Appendix N

References; Related Land Use Plans; and Laws, Regulations, and Agency Guidance

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ACHP (Advisory Council on Historic Preservation). 2016. Review of "no adverse effect" finding, Vernal Field Office Gas and Oil Lease Sales, Uintah and Duchesne Counties, Utah. December 12, 2016, letter from Reid J. Nelson, Director of the ACHP, to Ester McCullough, BLM Field Office Manager, Vernal Field Office, Utah.

______. 2017. Review of "no adverse effect" finding, Price Office Gas and Oil Lease Sales, Emery County, Utah. November 7, 2017, letter from Reid J. Nelson, Director of the ACHP, to Deborah Brown, BLM Acting Field Office Manager, Price Field Office, Utah.

______. 2018. Review of "no adverse effect" finding, Canyon Country Gas and Oil Lease Sale for March 2018, San Juan and Grand Counties, Utah. March 7, 2018, letter from Reid J. Nelson, Director of the ACHP, to Lance Porter, District Manager, BLM Canyon Country District, Utah.

______. 2019. Recent court decision regarding the meaning of "direct" in Sections 106 and 110(f) of the National Historic Preservation Act. June 7, 2019, memorandum from ACHP Office of General Counsel to ACHP staff, Washington DC.

Adams, M. B. 2011. "Land application of hydrofracturing fluids damages a deciduous forest stand in West Virginia." *Journal of Environmental Quality* 40(4):1340–1344.American Academy of Audiology. 2010. Levels of Noise in decibels (dB). Internet website: http://www.audiology.org/publications-resources/consumer-information/audiology-awareness/
posters.

American Academy of Audiology. 2010. Levels of Noise In decibels (dB). Internet website: https://audiology-web.s3.amazonaws.com/migrated/NoiseChart16x20.pdf_5399b28aaef0d9.27446344.pdf.

Archibald, J. David, Philip D. Gingerich, Everett H. Lindsay, William A. Clemens, David W. Krause, and Kenneth D. Rose. 1987. "First North American land mammal ages of the Cenozoic Era." *Cenozoic Mammals of North America*. University of California Press, Berkeley. Pp. 24–76.

Arizona Public Services Electric Company. 2017. Integrated Resource Plan. April 2017. Internet website: https://www.aps.com/-/media/APS/APSCOM-PDFs/About/Our-Company/Doing-business-with-us/Resource-Planning-and-Management/2017IntegratedResourcePlan.ashx?la=en&hash=150046DC45ABF903ADA3C458B97A3AED.

ATSDR (Agency for Toxic Substances and Disease Registry). 2014. Medical Management Guidelines for Hydrogen Sulfide. Internet website: https://www.atsdr.cdc.gov/mmg/mmg.asp?id=385&tid=67.

______. 2015. Public Health Statement for Benzene. Internet website: https://www.atsdr.cdc.gov/phs/phs.asp?id=37&tid=14.

Ayers W. B., Jr., and W. R. Kaiser (editors). 1994. Coal bed methane in the Upper Cretaceous Fruitland Formation, San Juan Basin, New Mexico and Colorado. New Mexico Bureau of Mines and Mineral Resources Bulletin 146. Internet website: https://geoinfo.nmt.edu/publications/monographs/bulletins/downloads/146/Bulletin146.pdf.

Begay, R. 2001. "Doo Dilzin Da: Abuse of the natural world." *American Indian Quarterly* 25(1):21–27.

Belnap, J., J. H. Kaltenecker, R. Rosentreter, J. Williams, S. Leonard, and D. Eldridge. 2001. Biological Soil Crusts: Ecology and Management. Technical Reference 1730-2. US Department of the Interior, Bureau of Land Management, National Science and Technology Center, Denver, Colorado. BLM/ID/ST-01/001+1730.

BIA (US Department of the Interior, Bureau of Indian Affairs). 2012. Indian Affairs National Environmental Policy Act (NEPA) Guidebook. 59 IAM 3-H. August 2012. US Department of the Interior, Bureau of Indian Affairs, Reston, Virginia.

______. 2013. Onshore Energy and Mineral Lease Management Interagency Standard Operating Procedures. Effective October 1, 2013. Washington, DC.

______. 2017. Livestock grazing trust data for the Northern Navajo (Shiprock) Agency. Unpublished data provided by Calvert L. Curley, BIA.

______. 2018. Livestock grazing trust data for the Eastern Navajo Agency. Unpublished data provided by Treva Henio, BIA.

BIA, BLM, Minerals Management Service, Indian Energy and Minerals Steering Committee. 2017. Memorandum of Agreement—Management of Federal Indian Minerals Office, Farmington, New Mexico.

BIA, BLM, Office of Natural Resources Revenue (ONRR), Office of Surface Mining (OSM), Office of the Special Trustee (OST), and Office of Indian Energy and Economic Development (IEED). 2013. Onshore Energy and Mineral Lease Management Interagency Standard Operating Procedures. Washington, DC.

BISON-M [Biota Information System of New Mexico]. 2018. Species Search. Internet website: http://www.bison-m.org/Index.aspx.

BLM (US Department of the Interior, Bureau of Land Management). 1984. Manual 8400 – Visual Resource Management. BLM, Washington, DC. April 5, 1984.

______. 2000. Final Environmental Impact Statement for Riparian and Aquatic Habitat Management in the Farmington Field Office – New Mexico, Volumes 1 and 2: Proposed Riparian and Aquatic Habitat Management Plan. August 2000. US Department of the Interior, Bureau of Land Management, Farmington, New Mexico.

______. 2003. Farmington Resource Management Plan with Record of Decision. December 2003. US Department of the Interior, Bureau of Land Management, Farmington, New Mexico.

______. 2005. Handbook H-1601-1—Land Use Planning Handbook. BLM, Washington, DC. March 11, 2005.

______. 2007. Final Vegetation Treatments Using Herbicides on the Bureau of Land Management Lands in 17 Western States Final Programmatic EIS Record of Decision. September 2007. US Department of the Interior, Bureau of Land Management, Washington, DC.

______. 2009. Approved Resource Management Plan Amendments/Record of Decision (ROD) for Designation of Energy Corridors on Bureau of Land Management-Administered Lands in the 11 Western States. January 2009. US Department of the Interior, Bureau of Land Management, Washington, DC.

______. 2010a. H2S Wells in the San Juan Basin. Internet website: https://publiclab.org/sites/default/files/H2S_Map_08302010_legal.pdf. Edited 08/30/2010.

______. 2010b. Instruction Memorandum No. NM-F00-2010-001. Migratory Bird Treaty Act – BLM/FFO Interim Management Policy.

______. 2012a. Manual 6310-Conducting Wilderness Characteristics Inventory on BLM Lands. Rel. 6-129. BLM, Washington, D.C. March 15, 2012.

______. 2012b. Approved Resource Management Plan Amendments and Record of Decision for Solar Energy Development in Six Southwestern States. Washington, DC. October 2012.

______. 2013. United States Department of the Interior Bureau of Land Management New Mexico State Office Plan Maintenance Change Sheet. Change Number 30. March 19, 2013.

______. 2014a. Decision Record for the Farmington Field Office Visual Resource Management Resource Management Plan Amendment. 2014. US Department of the Interior, Bureau of Land Management, Farmington, New Mexico.

______. 2014b. Scoping Report, Mancos-Gallup Resource Management Plan Amendment and Environmental Impact Statement. Farmington Field Office. November 2014

______. 2014c. United States Department of the Interior Bureau of Land Management New Mexico State Office Plan Maintenance Change Sheet. Change Number 34. April 3, 2014.

______. 2014d. Mancos-Gallup RMPA/EIS Socioeconomic Baseline Report. Internet website: http://www.blm.gov/style/medialib/blm/nm/field_offices/farmington/farmington_planning/ffo_planning_docs/rmpa_mancos/reports.Par.21357.File.dat/FFO_SEbaseline_20140904_newcover.pdf.

______. 2015a. Decision Record for the Glade Run Recreation Area Recreation and Travel Management Plan. BLM, Farmington Field Office.

______. 2015b. Mancos-Gallup Resource Management Plan Amendment and Environmental Impact Statement, Assessment of the Management Situation. Bureau of Land Management, Farmington Field Office. Farmington, New Mexico.

______. 2016a. Vegetation Treatments Using Aminopyralid Fluroxypyr and Rimsulfuron on BLM Lands in 17 Western States PEIS. August 2016. US Department of the Interior, Bureau of Land Management, Washington, DC.

______. 2016b. LR2000 Summary Report. Produced May 18, 2016. Farmington, New Mexico.

______. 2017. Farmington Mancos-Gallup Resource Management Plan Amendment and Environmental Impact Statement Scoping Report. May 2017. Farmington Field Office, Farmington, New Mexico.

______. 2018a. BLM New Mexico Special Status Plant List. Internet website: https://www.blm.gov/sites/blm.gov/files/IB%20NM-2019-002-Attachment%202%20Plants.pdf.

______. 2018b. BLM New Mexico Special Status Animal List. Internet website: https://www.blm.gov/sites/blm.gov/files/IB%20NM-2019-002_Attachment%201%20Animal.pdf.

______. 2018c. Air Resources Technical Report for Oil and Gas Development. New Mexico State Office, Santa Fe, New Mexico. March 2018.

______. 2019. Cumulative BLM New Mexico Greenhouse Gas Emissions Supplemental White Paper. Internet website: https://www.blm.gov/sites/blm.gov/files/Cumulative%20BLM%20New%20Mexico%20Greenhouse%20Gas%20Emissions%2C%20A%20Supplemental%20White%20Paper_Final_508%20CB.pdf.

BLM GIS. 2020. GIS developed for BLM alternatives and impact analysis, and base GIS data on file with BLM's eGIS server. BLM Farmington Field Office, New Mexico.

BLM, Ramboll Environ US Corporation, and Kleinfelder, Inc. 2016. Colorado Air Resource Management Modeling Study (CARMMS) with Updated Mancos Shale Modeling, 2021 Modeling Results for the High, Low and Medium Oil and Gas Development Scenarios. New Mexico State Office, Santa Fe, New Mexico. March 2016.

BOR (US Department of the Interior, Bureau of Reclamation). 2009. Navajo-Gallup Water Supply Project, New Mexico-Arizona, Final Environmental Impact Statement. Internet website: https://www.usbr.gov/uc/envdocs/eis/navgallup/FEIS/.

______. 2017. Navajo Indian Irrigation Project. Internet website: https://www.usbr.gov/projects/index.php?id=360

Boshell, C. 2010. Public Land Policy As A Cultural Empowerment Tool: The Federal Land Policy and Management Act of 1976 (FLPMA). NRPI 210 - Public Land Management, Humboldt State University, Spring 2010.

Boyd, Lynn. 2001. "Buffer Zones and Beyond: Wildlife Use of Wetland Buffer Zones and their Protection under the Massachusetts Wetland Protection Act." Wetland Conservation Professional Program, Department of Natural Resources Conservation, University of Massachusetts. Buseck, R, D. Keinath, and M. McGee. 2004. Species Assessment For Sage Thrasher (Oreoscoptes Montanus) in Wyoming. Available online at: http://www.uwyo.edu/wyndd/_files/docs/reports/speciesassessments/sagethrasher-dec2004.pdf.

Butler, J. L., M. A. Williams, P. J. Bottomley, and D. D. Myrold. 2003. "Microbial community dynamics associated with rhizosphere carbon flow." *Applied and Environmental Microbiology* 69(11):6793-6800.

Counselor Health Impact Assessment Committee. 2017. Health Impact Reports Summary. Internet website: https://www.nmlegis.gov/handouts/IAC%20100417%20Item%208%20Drilling%20on%20and%20Near%20Sacred%20Sites%203.pdf.

Craigg, Steven D. 2001. "Geologic Framework of the San Juan Structural Basin of New Mexico, Colorado, Arizona, and Utah, with Emphasis on Triassic through Tertiary Rocks." US Geological Survey Professional Paper 1420.

Crocker, K., and J. F. Glover. 2019. Reasonably Foreseeable Development Scenario for Oil and Gas Activities, Mancos-Gallup RMPA Planning Area, Farmington Field Office, northwestern New Mexico. United States Department of the Interior, Bureau of Land Management. March 2019.

CSU (Colorado State University, Cooperative Institute for Research in the Atmosphere (CIRA)). 2019. Mesa Verde National Park Dry Deposition Summary. Internet website: http://views.cira.colostate.edu/fed/SiteBrowser/Default.aspx?appkey=SBCF_DryDep.

DECRM (Division of Environmental and Cultural Resources Management, Bureau of Indian Affairs). 2012. Indian Affairs National Environmental Policy Act (NEPA) Guidebook 59 IAM 3-H. Reston, Virginia.

Dieter, A., et al. 2018. Estimated Use of Water in the United Stated in 2015. U.S. Geological Survey Circular 1441, 65 p., https://doi.org/10.3133/cir1441. [Supersedes USGS Open-File Report 2017–1131.]

EIA (Energy Information Administration). 2018. Annual Energy Outlook 2018, with projections to 2050. US Energy Information Administration Office of Energy Analysis, US Department of Energy, Washington, DC. #AEO2018.

EMNRD (New Mexico Energy, Minerals and Natural Resources Department Forestry Division). 2017. Endangered Plants. Internet website. http://www.emnrd.state.nm.us/SFD/ForestMgt/Endangered.html /

Engler, T. W., S. Kelley, and M. Cather. 2015. Reasonable Foreseeable Development (RFD) Scenario for Northern New Mexico. Open-file Report 567. New Mexico Bureau of Geology and Mineral Resources. New Mexico Institute of Mining & Technology. Socorro, New Mexico. January 2015.

EPA (US Environmental Protection Agency). 2011. Level III Ecoregions of the Continental United States, revised December 2011. National Health and Environmental Effects Research Laboratory, US Environmental Protection Agency. Internet website: http://www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm.

______. 2016a. 2014 National Emissions Inventory. Internet website: https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data. Version 1 released September 30, 2016.

______. 2016b. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. EPA-600-R-16-236ES. EPA, Office of Research and Development. Washington, DC. Executive Summary, Pp.1-2. Internet website: https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990.

______. 2016c. Promising Practices for EJ Methodologies in NEPA Reviews- Report of the Federal Interagency Working Group on Environmental Justice & NEPA Committee. Internet website: https://www.epa.gov/sites/production/files/2016-08/documents/nepa_promising_practices_document_2016.pdf.

______. 2018a. Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2016. Internet website: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

______. 2018b. Memorandum: Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program. April 17, 2018. Internet website: https://www.epa.gov/sites/production/files/2018-04/documents/sils_policy_guidance_document_final_signed_4-17-18.pdf.

______. 2019a. NAAQS Table. Internet website: https://www.epa.gov/criteria-air-pollutants/naaqs-table.

______. 2019b. New Mexico Nonattainment/Maintenance Status for Each County by Year for All Criteria Pollutants. Internet website: https://www3.epa.gov/airquality/greenbook/anayo_nm.html.

______. 2019c. EPA AirData Monitor Values Report. Internet website: https://www3.epa.gov/airdata.

______. 2019d. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017. Internet website: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017.

______. 2019e. Facility Level Information on Greenhouse Gases Tool. Internet website: https://ghgdata.epa.gov/ghgp/main.do.

Fassett, James E., and Spencer G. Lucas. 2000. "Evidence for Paleocene Dinosaurs in the Ojo Alamo Sandstone, San Juan Basin, New Mexico." Bulletin 17 - Dinosaurs of New Mexico. New Mexico Museum of Natural History and Science. Pp. 221-230.

FEMA GIS. 2017. National Flood Hazard Layer. Internet website: https://www.fema.gov/national-flood-hazard-layer-nfhl

Forest Service. 2007. Final Environmental Impact Statement Northern Rockies Lynx Management Direction Volume 1. National Forests in Montana, and parts of Idaho, Wyoming, and Utah.

Four Corners Air Quality Task Force. 2007. Four Corners Air Quality Task Force Report of Mitigation Options. Internet website: www.nmenv.state.nm.us/aqb/4C/Docs/4CAQTF_Report_FINAL_Introduction.pdf. November 1, 2007.

Fuller, Steven, P. Stirniman, and D. Silverman. 2017. A Cultural Resources Survey of the WPX Energy Production LLC's Rodeo Unit Number 508H-510H Dual Well Pad, Access Road, and Pipeline, San Juan County, New Mexico. La Plata Archaeological Consultants. LAC Report 2017-2k. Dolores, Colorado.

FWS GIS. 2016. National Wetlands Inventory GIS Data. Internet website: https://www.fws.gov/wetlands/Data/Data-Download.html.

Gannon, W. L. 1998. 1997 Bat Survey Final Report: Bureau of Land Management, Farmington District. Museum of Southwestern Biology, University of New Mexico, Albuquerque, *cited in* BLM 2003. Farmington Proposed Resource Management Plan and Final Environmental Impact Statement. BLM Farmington Field Office, Farmington, New Mexico.

Gilpin, Dennis, and Linda Thompson. 2013. A Class I Archaeological Inventory of the Navajo-Gallup Water Supply Project. PaleoWest Archaeology, Phoenix, Arizona.

Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K. Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: Southwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25.

Hall, Jean P., Donald L. Wolberg, and Stephen West. 1988. "Dinosaur-skin impressions from the Fruitland Formation (Campanian-Maastrichtian) of the Fossil Forest, San Juan Basin, San Juan County, New Mexico. Bulletin 122 – Contributions to Late Cretaceous Paleontology and Stratigraphy of New Mexico, Part III. New Mexico Bureau of Mines and Mineral Resources, Socorro. Pp. 23-27.

Headwaters Economics. 2017. Economic Profile System Data for McKinley, Rio Arriba, Sandoval, and San Juan Counties, New Mexico. Internet website: http://headwaterseconomics.org/tools/economic-profile-system.

Horwitz, Sari. 2014. Dark Side of the Boom: North Dakota's Oil Rush Brings Cash and Promise to Reservation, Along with Drug-fueled crime. The Washington Post. Internet website: https://www.washingtonpost.com/sf/national/2014/09/28/dark-side-of-the-boom/?noredirect=on&utm_term=.940c26fc2056. September 28, 2014.

Hunt, Adrian P., and Spencer G. Lucas. 1992. "Stratigraphy, paleontology and age of the Fruitland and Kirtland Formations (Upper Cretaceous), San Juan Basin, New Mexico." New Mexico Geological Society Guidebook, 43rd Field Conference, San Juan Basin IV. New Mexico Geological Society. Pages 217–240.

IDEM (Indiana Department of Environmental Management). 2003. Public Comment on Docket ID no. OW-2002-0050. April 16, 2003. Internet website: https://earthjustice.org/sites/default/files/library/legal_docs/IN-20DEM-201391.pdf.

IMPLAN Group, LLC. IMPLAN Pro 2017. Huntersville, NC. IMPLAN.com.

Johansen, J. R., L. L. St. Clair, B. L. Webb, and G. T. Nebeker. 1984. "Recovery patterns of cryptogamic soil crusts in desert rangelands following fire disturbance." *Bryologist* 87(3):238-243.

Johnson, Kristine, Lynn Wickersham, Jacqueline Smith, Nathan Petersen, and John Wickersham. 2015. Nest-scale Habitat Use by Pinyon Jay and Gray Vireo in the BLM Farmington Resource Area 2013−2014 Final Report. Internet website: https://www.researchgate.net/publication/284187643_Nest-scale_habitat_use_by_Pinyon_Jay_and_Gray_Vireo_in_the_BLM_Farmington_resource_area_2013-2014_Final_Report.

Kues, Barry S. 2008. *The Paleontology of New Mexico*. University of New Mexico Press, Albuquerque.

La Plata County. 2002. La Plata County Final Impact Report. Durango, Colorado. October 2002.

Lee, K. H., T. M. Isenhart, and R. C. Schultz. 2003. "Sediment and nutrient removal in an established multi-species riparian buffer." *Journal of Soil and Water Conservation* 58:1–8.

Lewis, J., J. Hoover, and D. MacKenzie. 2017. Mining and Environmental Health Disparities in Native American Communities. Current Environmental Health Reports vol. 4, Issue, 2. Internet website: https://doi.org/10.1007/s40572-017-0140-5.

Longcore, Travis, and Catherine Rich. 2004. Ecological Light Pollution. Frontiers in Ecology and the Environment. 2:4. Internet website: https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/1540-9295%282004%29002%5B0191%3AELP%5D2.0.CO%3B2. Accessed April 2018.

Lucas, Spencer G., Adrian P. Hunt, and Randy Pence. 1988. "Some Late Cretaceous Reptiles from New Mexico." Bulletin 122 – Contributions to Late Cretaceous paleontology and stratigraphy of New Mexico, Part III. New Mexico Bureau of Mines and Mineral Resources, Socorro. Pp. 49–60.

Lucas, Spencer G., and Thomas E. Williamson. 1992. "Fossil mammals and the early Eocene age of the San Jose Formation, San Juan Basin, New Mexico." New Mexico Geological Society Guidebook, 43rd Field Conference, San Juan Basin IV. New Mexico Geological Society. Pp. 311–316.

Lucas, Spencer G., Robert M. Sullivan, Steven M. Cather, Steven E. Jasinski, Denver W. Fowler, Andrew B. Heckert, Justin A. Spielmann, and Adrian P. Hunt. 2009. "No definitive evidence of Paleocene dinosaurs in the San Juan Basin." *Palaeontologia Electronica* 12(2).

Muldavin, E., R. Sivinski, M. East, Y. Chauvin, and Mark Horner. 2016. Brack's hardwall cactus distribution, habitat, and status survey 2015. Unpublished report prepared for the BLM State Office, Santa Fe, NM by Natural Heritage New Mexico, Museum of Southwestern Biology and Department of Biology, University of New Mexico, Albuquerque, NM. 61 pp. Internet website: https://nhnm.unm.edu/sites/default/files/nonsensitive/publications//NHNM_BracksCactus2015SurveyReport_Final20160506.pdf.

National Academy of Sciences. 2012. Induced seismicity potential in energy technologies. National Academies Press, Washington, DC.

Natural Gas Intel. 2018. Information on the San Juan Basin. Internet website: http://www.naturalgasintel.com/sanjuaninfo.

NatureServe. 2014. NatureServe Explorer: An online encyclopedia of life. Internet website: www.natureserve.org/explorer.

Navajo Agricultural Products Industry. 2017. History. Internet website: http://www.navajopride.com/index.php/history/.

Navajo Forestry Department. 2017. Navajo Forestlands Integrated Resource Management Plan. Internet website: https://navajoirmp.wixsite.com/irmp.

Navajo Nation. 2001. Navajo Nation Ten-Year Forest Management Plan.

______. 2002. San Juan Chapter Community-Based Land Use Plan. Fruitland, New Mexico.

______. 2008a. Navajo Endangered Species List. September 10, 2008. Internet website: https://www.nndfw.org/nnhp/nnhp_nesl.pdf.

______. 2008b. Biological Resource Land Use Clearance Policies and Procedures (RCP). RCS-44-08. September 10.

______. Undated. Draft Navajo Nation Woodland Management Plan.

Navajo Nation Code. 2009. Title 19 Parks and Monuments. Internet website: http://www.navajonationcouncil.org/Code%20Page.html. December 2009.Navajo Natural Heritage Program. 1994. Draft Guidance, Navajo Nation Aquatic Resources Protection Plan. Window Rock, Arizona.

Navajo-tec. 2017. Navajo Mine: A brief history. Internet website: http://www.navajo-tec.com/history.html.

New Mexico Department of Game and Fish. 2016a. Threatened and Endangered Species of New Mexico. 2016 Biennial Review. Available online at: http://www.wildlife.state.nm.us/download/conservation/threatened-endangered-species/biennial-reviews/2016-Biennial-Review-FINAL.pdf. Accessed on February 9, 2018.

______. 2016b. State Wildlife Action Plan for New Mexico. Available online at: http://www.wildlife.state.nm.us/download/conservation/swap/New-Mexico-State-Wildlife-Action-Plan-SWAP-Final-2017.pdf. Accessed on February 9, 2018.

New Mexico State University. 2014. Mule Deer in New Mexico. Guide L-301. Revised by Louis C. Bender and Chris Allison. Internet website: https://aces.nmsu.edu/pubs/_l/L301.pdf.

NHD GIS. 2016. National Hydrography Dataset (NHD) published GIS data on surface water and watersheds. Internet website: nhd.usgs.gov/data.html. June 2016.

NMBGMR (New Mexico Bureau Geology and Mineral Resources). 2014. Hydrologic Assessment of Oil and Gas Resource Development of the Mancos Shale in the San Juan Basin, New Mexico. Socorro, New Mexico. November 2014.

NMDA (New Mexico Department of Agriculture). 2016. New Mexico Noxious Weed List Update. Internet website: www.nmda.nmsu.edu/apr/noxious-weed-information/.

NMDGF (New Mexico Department of Game and Fish). 2017. Restoration and Management of Native and Non-native Trees in Southwestern Riparian Ecosystems. Internet website: http://www.wildlife.state.nm.us/download/conservation/habitat-handbook/project-guidelines/feature/Restoration-and-Management-of-Native-and-Non-native-Trees-in-Southwestern-Riparian-Ecosystems-2017.pdf.

______. 2018. Annual Harvest Report 2017-2018. http://www.wildlife.state.nm.us/hunting/harvest-reporting-information/.

NMDOT (New Mexico Department of Transportation). 2017a. 2016 Community Report: McKinley County. Geospatial and Population Studies Traffic Research Unit, University of New Mexico, Albuquerque.

______. 2017b. 2016 Community Report: Rio Arriba County. Geospatial and Population Studies Traffic Research Unit, University of New Mexico, Albuquerque.

______. 2017c. 2016 Community Report: Sandoval County. Geospatial and Population Studies Traffic Research Unit, University of New Mexico, Albuquerque.

______. 2017d. 2016 Community Report: San Juan County. Geospatial and Population Studies Traffic Research Unit, University of New Mexico, Albuquerque.

NMED (New Mexico Environment Department). 2016. Inventory of New Mexico Greenhouse Gas Emissions: 2000 – 2013. Internet website: https://www.env.nm.gov/wp-content/uploads/2017/01/NM_GHGInventory_2013_Update.pdf. December 9.

______. 2019. Ozone Attainment Initiative. Internet website: https:.//www.env.nm.gov/air-quality/o3-initiative/

NMEMNRD (New Mexico Energy, Minerals and Natural Resources Department). 2016. Annual Report 2016. Santa Fe, New Mexico Internet website: http://www.emnrd.state.nm.us/ADMIN/documents/Final_2016_EMNRD_AnnualReport.pdf.

NMOCD (New Mexico Oil Conservation Division). 2005. Hydrogen Sulfide: Issues and Answers Workshop. Internet website: http://octane.nmt.edu/sw-pttc/proceedings/H2S_05/HydrogenSulfide_OCD.pdf. December 7, 2005.

NMOSE. 2019. Notice of Intent for deep wells filed under Section 72-12-25 through 72-12-28 New Mexico Statutes Annotated. Santa Fe, New Mexico.

NMOSE/ISC (New Mexico Office of the State Engineer/Interstate Stream Commission). 2017. Navajo Nation Water Rights Settlement. Internet website: http://www.ose.state.nm.us/Legal/settlements/NNWRS/index.php.

______. 2018. New Mexico Water Rights Reporting System; Water Rights Lookup. Internet website: http://nmwrrs.ose.state.nm.us/nmwrrs/index.html.

NNDFW (Navajo Nation Department of Fish and Wildlife). 2018. Navajo Hunting Proclamation 2018-2019. NNDFW, Window Rock, Arizona.

______. 2019. The Navajo Nation's Big Game Hunting Units. Internet website: https://www.nndfw.org/hunt_unit_maps/hunt_unit.htm.

NNEPA (Navajo Nation Environmental Protection Agency). 2017a. Annual Ambient Air Monitoring Report. Counselor, New Mexico. September.

______. 2017b. Navajo Nation Clean Water Act. Internet website: http://www.navajonationepa.org/Pdf%20files/Clean%20Water.pdf.

North American Coal. 2016. About. Internet website: http://www.nacoal.com/operations/BistiFuels.shtml.

NPS (National Park Service). 2002. How to Apply the National Register Criteria for Evaluation. National Register Bulletin 15. Internet website: https://www.nps.gov/nr/publications/bulletins/pdfs/nrb15.pdf.

______. 2006. Management Policies 2006. Internet Website: https://www.nps.gov/policy/MP_2006.pdf.

______. 2014. Chaco Cultural National Historical Park, Chaco Night Sky Program. Internet website: www.nps.gov/chcu/planyourvisit/nightsky.htm.

Office of Pipeline Safety. 2005. Pipeline and Hazardous Materials Safety Administration, Washington, DC. Internet website: http://ops.dot.gov/.

OSHA (Occupational Safety and Health Administration). 2018. Hydrogen Sulfide. Internet website: https://www.osha.gov/SLTC/hydrogensulfide/standards.html.

Papadopoulos and Associates. 2007. Piceance Basin Phase IV Baseline Water Quality Study – Garfield County, Colorado. Prepared for Colorado Oil and Gas Conservation Commission. Internet website: http://cogcc.state.co.us/Library/PiceanceBasin/BaselineH20_PhaseIV_study_TEXT.pdf.

PNM (Public Service Company of New Mexico). 2017. Integrated Resource Plan, 2017-2036. Internet website: https://www.pnm.com/documents/396023/396193/PNM+2017+IRP_Executive+Summary.pdf/992f1578-8eb1-4454-a51e-7ea19cf39833.

Post van der Burg, and Brian A. Tangen. 2015. "Monitoring and modeling wetland chloride concentrations in relationship to oil and gas development." *Journal of Environmental Management* 150(2015): 120–127. ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2014.10.028.

Rio Puerco Alliance and Hasbiditio. 2013. Tri-Chapter Food and Energy Economic Survey Results. Internet website: https://e7ebe098-ee23-4eb3-9a55-df963ec4cf3f.filesusr.com/ugd/0d0f49_8f6ffd91cb3048f0b78246985292e188.pdf.

Rosenberg, K., et al. 2019. Decline of North American Avifauna. Science. Internet website: https://www.birds.cornell.edu/home/wp-content/uploads/2019/09/DECLINE-OF-NORTH-AMERICAN-AVIFAUNA-SCIENCE-2019.pdf.

Sada, D. W., and K. F. Pohlman. 2002. "Spring inventory and monitoring protocols." Conference proceedings. Spring-Fed Wetlands: Important Scientific and Cultural Resources of the Intermountain Region. Internet website: https://www.dri.edu/images/stories/conferences_and_workshops/spring-fed-wetlands/spring-fed-wetlands-sada-pohlmann-protocol.pdf.

San Juan County. 2011. San Juan County Community Health Profile. Internet website: http://www.nmhealthcouncils.org/Resources/Pictures/SanJuanProfile_060714.pdf.

Sarche, Michelle, and Paul Spicer. 2009. Poverty and Health Disparities for American Indian and Alaska Native Children: Current Knowledge and Future Prospects. National Instituties of Health. University of Colorado Devner, American Indian and Alaska Native Program. Aurora, Colorado

Sawyer, H. and Kauffman, M. 2009. Identifying mule deer migration routes to and from the Pinedale Anticline Project Area. Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming. Internet website: https://wyocoopunit.org/wp-content/uploads/SER_report-_Sawyer_and_Kauffman_2009.pdf.

Sawyer et al. 2006. Winter Habitat Selection of Mule Deer Before and During Development of a Natural Gas Field. Internet website: http://migrationinitiative.org/sites/migration.wygisc.org/themes/responsive_blog/images/Sawyer-etal-2006.pdf.

Sealey, Paul L., and Spencer G. Lucas. 1997. "Paleontology, Stratigraphy and Biostratigraphy of the Upper Cretaceous Lewis Shale near Waterflow, San Juan County, New Mexico." New Mexico Geological Society Guidebook, 48th Field Conference, Mesozoic Geology and Paleontology of the Four Corners Region. New Mexico Geological Society. Pp. 233–238.

Smith, M. D., R. S. Krannich, and L. M. Hunter. 2001. "Growth, decline, stability, and disruption: A longitudinal analysis of social well-being in four western rural communities." *Rural Sociology* 66: 425–450.

Sutter, Lori, Nathaniel Weston, and Steven Goldsmith. (2015). Hydraulic Fracturing: Potential Impacts [on] Wetlands. 32:7–16. Internet website: https://www.researchgate.net/publication/282860011_Hydraulic_Fracturing_Potential_Impacts_to_Wetlands.

US Census Bureau. 2010. Census 2010, Summary File 1, Table DP-1 and Summary File 3, Table DP-3; American FactFinder. Internet website: http://factfinder2.census.gov.

______. 2015. American Community Survey, 2010-2015 American Community Survey 5-Year Estimates, Tables DP-02, DP-03, DP-04, DP-05; American FactFinder. Internet website: http://factfinder2.census.gov.

______. 2016. Poverty threshold by size of family. Internet website: http://www.census.gov/hhes/www/poverty/data/threshld/index.html.

USACE (US Army Corps of Engineers). 1987. Corps of Engineers Wetlands Delineation Manual. Environmental Laboratory US Army Corps of Engineers, Waterways Experiment Station, Wetlands Research Program Technical Report Y-87-1. Vicksburg, Mississippi. Internet website: http://www.lrh.usace.army.mil/Portals/38/docs/USACE%2087%20Wetland%20Delineation%20 Manual.pdf.USDA, USDOI, and USEPA. 2011. Memorandum of Understanding Regarding Air Quality Analyses and Mitigation for Federal Oil and Gas Decisions Through the National Environmental Policy Act Process. Internet website: https://www.epa.gov/sites/production/files/2014-08/documents/air-quality-analyses-mou-2011.pdf.

USDOI (United States Department of the Interior). 2013. Best Management Practices for Reducing Visual Impacts of Renewable Energy Facilities on BLM-Administered Lands. Bureau of Land Management. Cheyenne, Wyoming. April.

USFWS (US Fish and Wildlife Service). 2016, 2018. ECOS Environmental Conservation Online System. Internet website: https://ecos.fws.gov/ecp/.

______. 2019. Entrapment, Entanglement and Drowning. Internet website: https://www.fws.gov/birds/bird-enthusiasts/threats-to-birds/entrapment-entanglement-drowning.php.USGS (US Geological Survey). 2001. Groundwater Atlas of the United States—Arizona, Colorado, New Mexico, Utah: HA 730-C. Colorado Plateaus Aquifer. Internet website: http://pubs.usgs.gov/ha/ha730/ch_c/C-text8.html.

______. 2012. Water Quality Studied in Areas of Unconventional Oil and Gas Development, Including Areas Where Hydraulic Fracturing Techniques are Used, in the United States. US Geological Survey Powell Center for Analysis and Synthesis. Fact Sheet 2012-3049. April 2012.

______. 2014. New Mexico 2014 Seismic Hazard Map. Internet website: https://earthquake.usgs.gov/earthquakes/byregion/newmexico-haz.php.

Valdez et al. 2019. New Mexico Water Use by Categories 2015. New Mexico State Engineer Office, Technical Report 55, May 2019. Internet website: https://www.ose.state.nm.us/Pub/wucTechReports/2015/2015%20WUR%20final_05142019.pdf.

Vijayaraghavan et al. 2017. Colorado Air Resource Management Modeling Study (CARMMS) with Updated Mancos Shale Modeling: 2025 Modeling Results for the High, Low, and Medium Oil and Gas Development Scenarios. CARMMS 2.0. Internet website: https://www.blm.gov/documents/colorado/public-room/report.

Warpinski, N. R. 2011. "Fracture growth in layered and discontinuous media." Proceedings of the Technical Workshops for the Hydraulic Fracturing Study: Fate and Transport. US Environmental Protection Agency, Washington, DC. May 2011.

Warpinski, N. R., J. Du, and U. Zimmer. 2012. "Measurements of hydraulic-fracture induced seismicity in gas shales." Paper SPE 151597, presented at the SPE Hydraulic Fracture Technology Conference, The Woodlands, Texas. February 6 to 8, 2012.

WFDSS (Wildland Fire Decision Support System) GIS. 2009. Class I airshed data.

Williamson, Thomas E. 1996. "The beginning of the age of mammals in the San Juan Basin, New Mexico: Biostratigraphy and evolution of Paleocene mammals of the Nacimiento Formation." Bulletin 8. New Mexico Museum of Natural History and Science, Albuquerque, New Mexico.

Williamson, Thomas E., and Spencer G. Lucas. 1992. Stratigraphy and mammalian biostratigraphy of the Paleocene Nacimiento Formation, southern San Juan Basin, New Mexico. New Mexico Geological Society Guidebook, 43rd Field Conference, San Juan Basin IV. New Mexico Geological Society. Pp. 265–296.Witter, Roxana, Lisa McKenzie, Kaylan Stinson, Kenneth Scott, Lee S. Newman, and John Adgate. 2008. "The Use of Health Impact Assessment for a Community Undergoing Natural Gas Development. Framing Health Matters." *American Journal of Public Health* 103(6). June 2013.

Witter, R., et al. 2008. Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008). Colorado School of Public Health, University of Colorado Denver. Internet website: http://www.aph.gov.au/DocumentStore.ashx?id=d4314bfd-05e6-493c-942b-3c5ebf065f74.

Wolberg, Donald L., Stephen West, Jean P. Hall, and Jiri Zidek. 1988. "Probable caddisfly (Trichoptera: Insecta) larval cases from the Fruitland Formation (Campanian-Maastrichtian) of the Fossil Forest, San Juan County, New Mexico." Bulletin 122 – Contributions to Late Cretaceous paleontology and stratigraphy of New Mexico, Part III. New Mexico Bureau of Mines and Mineral Resources, Socorro. Pp. 29–31.

WRI (World Resources Institute). 2019a. CAIT Climate Data Explorer. 2019. Historical Emissions, Country GHG Emissions. Internet website http://cait.wri.org/historical/Country%20GHG%20Emissions?indicator[]=Total%20GHG%20Emissions%20Excluding%20Land-Use%20Change%20and%20Forestry&indicator[]=Total%20GHG%20Emissions%20Including%20Land-Use%20Change%20and%20Forestry&year[]=2014&sortIdx=NaN&chartType=geo.

_____. 2019b. CAIT Climate Data Explorer. 2019. Historical Emissions, US State GHG Emissions. Internet website: http://cait.wri.org/historical/US%20State%20GHG%20Emissions?indicator[]=Total%20GHG%20Emissions%20Excluding%20Land-Use%20Change%20and%20Forestry&indicator[]=Total%20GHG%20Emissions%20Including%20Land-Use%20Change%20and%20Forestry&year[]=2014&sortIdx=NaN&chartType=geo.

WUG. 1992. Western Regional Corridor Study. 1992. Sierra Pacific Power Company, Reno, Nevada.

_____. 2002. Priority Corridors with National Landscape Conservation System Data. BLM Update of the WUG Western Regional Corridor Study of 1993. September.

Zoback, Mary L., and Mark D. Zoback. 1989. Tectonic stress field of the continental United States. Geological Society of America. Memoir 172.

N.2 Related Land Use Plans

The BLM considered its current RMPs for lands next to the planning area in the development of this RMPA/EIS, including the Rio Puerco (BLM 1986) and Taos (BLM 2012) Field Office RMPs in New Mexico, as well as the San Juan/San Miguel Field Office (BLM 1985) and Tres Rios (BLM 2015b) RMPs in Colorado.

The BLM is revising the existing RMP for the Rio Puerco Field Office. The FFO has coordinated with the Rio Puerco Field Office in consideration of its pending planning decisions.

The RMPA/EIS will strive for consistency with the following programmatic EISs:

- Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic EIS, 2007
- West-wide Energy Corridor Programmatic EIS, 2009
- Final Programmatic Environmental Impact Statement for Vegetation Treatments Using Aminopyralid, Fluroxypyr, and Rimsulfuron on Bureau of Land Management Lands in 17 Western States, 2016a

Additionally, the following are federal, state, Tribal, and local government plans considered during the development of the draft RMPA/EIS:

Federal

- Aztec Ruins National Monument General Management Plan (NPS 2010)
- Chaco Culture National Historic Park General Management Plan (NPS 1985)
- Farmington Field Office Visual Resource Management Resource Management Plan Amendment (BLM 2014a)

State

- New Mexico Comprehensive Wildlife Conservation Strategy (New Mexico Department of Fish and Game 2006)
- New Mexico State Parks, Navajo Lake Management Plans, Lakeside (NMSP 2012) and Riverside (NMSP 2014)
- New Mexico State Water Plan (New Mexico Office of the State Engineer/Interstate Stream Commission 2003)
- The New Mexico 2040 Plan NMDOT's Long Range, Multi-Modal Transportation Plan (New Mexico Department of Transportation 2015)

Tribal and Local Government

- Animas River Trails System Plan, 2010 (Aztec Trails and Open Space and City of Aztec 2010)
- Bloomfield Comprehensive Plan, 2007 (Northwest New Mexico Council of Governments 2007)
- City of Aztec Comprehensive Plan, 2002 (Sites Southwest 2002)
- City of Farmington Comprehensive Plan, 2002 (Wilbur Smith Associates et al. 2002)
- La Plata County Comprehensive Plan (Colorado), 2001 (County of La Plata 2001)
- McKinley County Comprehensive Plan, 2003 (County of McKinley 2003)
- Navajo Nation, Biological Resource Land Use Clearance Policy and Procedures (Navajo Nation 2008)
- Navajo Nation, Chapter House Community-Based Land Use Plans
- Navajo Nation Cultural Resources Protection Act (CMY-19-88)
- Navajo Nation, Policy for the Disposition of Cultural Resources Collection
- Navajo Nation Natural Heritage Program's Biological Resource Land Use Clearance Policies
- Comprehensive Plan County of Rio Arriba (County of Rio Arriba 2014)
- Sandoval County Comprehensive Plan, 2013 (County of Sandoval 2013)
- San Juan County Growth Management Plan Update (County of San Juan 2012)

N.3 Laws, Regulations, and Agency Guidance

Table N-1 and the list that follows identify the applicable laws and regulations and provide an overview of the regulatory framework for this RMPA/EIS, as well as the procedures undertaken to ensure that the RMPA/EIS and any future site-specific actions taken under it are in compliance with the relevant laws and regulations. It is not considered exhaustive as some resource-specific regulations are discussed individually in the resource sections of **Chapter 3** in the RMPA/EIS. Further, not all laws, regulations, or guidance apply to both the BLM and BIA. For example, certain BLM guidance or state regulations only apply to that agency, and certain Tribal laws or regulations may only apply to the BIA. The Mancos-Gallup RMPA/EIS Analysis of the Management Situation also contains a list of laws and regulations specific to each resource program. It is available on the BLM ePlanning website for this project.

Table N-1
Actions Requiring Environmental Compliance Beyond NEPA

Action	Entities Involved	Type of Compliance Planned
Analysis of impacts on fish and wildlife in the surrounding area under the Fish and Wildlife Coordination Act (16 US Code 661-666c)	BLM, BIA, USFWS, New Mexico Department of Game and Fish	Release of Biological Assessment/ Biological Evaluation to inform subsequent ESA consultation
Assessment of coverage for the RMPA/EIS pursuant to Section 7 of the Endangered Species Act (ESA)	BLM, USFWS – Endangered Species Office	Biological Assessment/Biological Opinion, and a finding on if and how much the action will affect endangered species found in the project area
Assessment of National Historic Preservation Act (NHPA) coverage through Class III cultural resource surveys and Section 106 and government-to-government consultation, followed by execution of a Programmatic Agreement	BLM, BIA, Navajo Nation Chapters, Historic Preservation Officers, New Mexico State Historic Preservation Officer	Class III Cultural Resource Surveys, Consultation, Programmatic Agreement
Acquisition of permits under Sections 401 and 404 of the Clean Water Act	BLM, BIA, US Army Corps of Engineers, New Mexico Environment Department	Section 401/404 Permits
Air Quality Monitoring to Continue Evaluation of Attainment Status pursuant to the Clean Air Act	BLM, BIA, New Mexico Environment Department, Environmental Protection Agency, Four Corners Regional Ozone Task Force	Clean Air Action Plan
Acquisition of APD by meeting the requirements of Onshore Oil and Gas Orders	BLM, BIA, consulting surface management agency, operator seeking APD	APD, Drilling Plan, Surface Use Plan of Operations
Acquisition of permits and demonstrating industry compliance with statewide rules and statues as required by the New Mexico Oil and Gas Act (N.M. Stat. § 70-2-1–38) and related statutory provisions, including the Surface Owners Protection Act (§ 70-12-1–10), as well as the Air Quality Control Act (N.M. Stat. § 74-2-1–22) and the Water Quality Act (N.M. Stat. § 74-6-1–16) and their supporting rules and regulations, as administered through the New Mexico Environment Department (NMED)	operator, NMOCD, NMED	Relevant permits required to demonstrate compliance

Table N-1
Actions Requiring Environmental Compliance Beyond NEPA

Action	Entities Involved	Type of Compliance Planned
Acquisition of any relevant state and federal permits or other forms of consultation as required through the Underground Injection Control program under the Safe Water Drinking Act (42 USC § 300f et seq.) and their supporting rules and regulations, as well as New Mexico statutes, rules and regulations protecting drinking water, groundwater, and surface water quality	EPA, NMED Drinking Water Bureau, the New Mexico Water Quality Control Commission, NMOCD, the operator	Any relevant permitting associated with SDWA and the UIC and the relevant New Mexico statutes, rules, and regulations
Acquisition of any permitting or other forms of compliance pursuant to the Navajo Nation Clean Water Act (4 NNC § 1301 et. seq.), Navajo Nation Surface Water Quality Standards, etc.	Navajo Nation EPA	Permitting or other compliance in accordance with these laws and the NNPDES Program Regulations
Acquisition of any permitting or other forms of compliance pursuant to the Navajo Nation Safe Drinking Water Act (22 NNC § 2501 et. seq.) and Navajo Nation Underground Injection Control Regulations	Navajo Nation EPA	Permitting or other compliance in accordance with these laws, rules, and regulations
Acquisition of any permitting or other forms of compliance pursuant to the Navajo Nation Air Pollution Prevention and Control Act (4 NNC § 1101 et. seq.) as well as the Navajo Nation Air Quality Control Program Regulations	Navajo Nation EPA	Operating permit pursuant to the air quality control program and any other permitting or compliance in accordance with these laws, rules, and regulations
Acquisition of any permitting or other forms of compliance pursuant to the Navajo Nation Environmental Policy Act (4 NNC § 801 et. seq.)	Navajo Nation EPA	Any permitting or compliance in accordance with these laws, rules, and regulations

N.3.1 Federal

Laws and Regulations

- National Environmental Policy Act of 1969 (NEPA) (Public Law [PL] 91-190; 83 Stat. 852; 42 USC § 4321 et seq.)
- Council on Environmental Quality Executive Office of the President, Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (40 Code of Federal Regulations [CFR] §§ 1500-1508)
- Federal Land Policy and Management Act of 1976 (FLPMA) (PL 94-579; 90 Stat. 2743; 43 USC 35 § 1701 et seq.)
- Mineral Leasing Act of 1920 as amended (MLA) (41 Stat. 437; 30 USC § 181 et seq.)
- Mining and Minerals Policy Act of 1970 (30 USC § 21 et seq.)
- National Materials and Minerals Policy Research and Development Act of 1980 (PL 96-479)

- Federal Onshore Oil and Gas Leasing Reform Act of 1987 (30 USC § 181 et seq.)
- Indian Mineral Leasing Act of 1938 (25 USC §§ 396a-g)
- Indian Mineral Development Act of 1982 (25 USC § 2101 et seq.)
- Rights of Way Over Indian Land (25 USC § 323; 25 CFR § 169)
- Clean Water Act (PL 92-500; 86 Stat. 816; 33 USC §§ 1251-1387)
- Clean Air Act (PL 88-206; 77 Stat. 392; 42 USC 85.1 § 7401 et seq.)
- National Historic Preservation Act of 1966 (NHPA) (PL 89-665; 80 Stat. 915; 54 USC 300101 et seq. and Implementing Regulations at 36 CFR § 800)
- Archaeological Resources Protection Act of 1979 (PL 96-95; 93 Stat. 721; 16 USC, § 470aa) and Implementing Regulations at 36 CFR § 296
- American Indian Religious Freedom Act of 1978 (PL 95-341; 92 Stat. 469; 42 USC § 1996)
- Native American Graves Protection and Repatriation Act of 1990 (25 USC § 3001)
- Title V—Chaco Culture National Historical Park (Chaco Sites Protection Act) (PL 96-550)
- Chacoan Outliers Protection Act of 1995 (PL 104-11; 109 Stat. 158; 16 USC § 410ii)
- Wilderness Act of 1964 (PL 88-577; 11 USC § 1131 et. seq.)
- San Juan Basin Wilderness Protection Act of 1984 (PL 98–603; 98 Stat. 3155; 110 Stat. 4211)
- Omnibus Parks and Public Lands Management Act of 1996 (PL 104-333)
- John D. Dingell Jr. Conservation, Management and Recreation Act (PL-116-9 Sec. 1121. San Juan County Settlement Implementation)
- BIA Grazing (25 CFR § 166)
- Onshore Oil and Gas Order No. 1 – Approval of Operations on Onshore Federal and Indian Oil and Gas Leases (43 CFR 3160)

Executive Orders

- Executive Order (EO) 13175, Consultation and Coordination with Indian Tribal Governments (65 Federal Register [FR] 67249)
- EO 13007, Indian Sacred Sites (61 FR 26771-26772)
- EO 13186, Responsibility of Federal Agencies to Protect Migratory Birds (66 FR 3853-3856)
- EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (59 FR 7629)
- EO 13045, Protection of Children from Environmental Health Risks and Safety Risks
- EO 13783, Promoting Energy Independence and Economic Growth (82 FR 16093-16097)
- EO 13790, Promoting Agriculture and Rural Prosperity in America (82 FR 20237-20239)

Agency Guidance

- BLM NEPA Handbook (H-1790-1; *revision in progress*)
- BLM Manual MS1601—Land Use Planning
- BLM Land Use and Planning Handbook (H-1601-1)
- BLM Manual 6320—Considering Lands with Wilderness Characteristics in the BLM Land Use Planning Process
- BIA Fluid Mineral Estate Procedural Handbook (52 IAM X-H)
- BIA NEPA Guidebook (59 IAM 3-H)
- Onshore Energy and Mineral Lease Management Interagency Standard Operating Procedures (Interagency SOP 2013)
- Secretarial Order (SO) 3355, Streamlining National Environmental Policy Act Reviews and Implementation of Executive Order 13807

- Secretarial Order 3373, Evaluating Public Access in Bureau of Land Management Public Land Disposals and Exchanges

N.3.2 State

- New Mexico's Air Quality Act (20.2.3 New Mexico Administrative Code [NMAC])

N.3.3 Tribal

- Navajo Nation Clean Water Act (NNC Title 4)
- Navajo Nation Safe Water Drinking Act (NNC Title 22, Chapter 11, Subchapter 15)
- Navajo Nation Environmental Policy Act (NNC Title 4, Chapter 9, Subchapters 901-906)
- Navajo Nation Off-Reservation Grazing (NNC Title 3, Subsections 931-950)
- Navajo Nation Tribal Ranch Leases (NNC Title 3, Subsection 503)
- Navajo Nation Cultural Resources Protection Act (NNC Title 19 Chapter 11–Sections 1001-1061)
- Navajo Nation's Policy to Protect Traditional Cultural Properties
- Guidelines for the Treatment of Historic, Modern, and Contemporary Abandoned Sites
- Navajo Nation Policy for the Protection of Jishchaa'
- Navajo Nation Surface Management Stipulations
- Navajo Nation Department of Fish and Wildlife, Biological Resource Land Use Clearance Policies and Procedures (RCS-44-08)
- Navajo Nation Department of Fish and Wildlife, Navajo Natural Heritage Program, Endangered Species List Species Accounts

Appendix O
Cooperating Agencies

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Appendix O. Cooperating Agencies

Table O-1, below, lists the entities that have been invited to participate as cooperating agencies in the Farmington Mancos-Gallup RMPA/EIS process. The status column indicates their response to the invitation, if one has been received. A status of "pending" means no response has been received to date.

Table O-1
Cooperating Agency Participation

Agency/Tribe Invited to be a Cooperating Agency	Status
US Department of Agriculture, Forest Service, Carson National Forest, Jicarilla Ranger District	Pending
All Pueblos Council of Governors	Accepted
Navajo Nation – Division of Natural Resources	Accepted
Navajo Nation, Historic Preservation Department/Traditional Culture Program	Accepted
New Mexico Department of Cultural Affairs, Historic Preservation Division	Accepted
US Department of Agriculture, Forest Service, Santa Fe National Forest	Accepted
US Department of the Interior, National Park Service, Chaco Culture National Historic Park	Accepted
US Department of the Interior, Bureau of Reclamation, Western Colorado Area Durango Field Office	Declined
US Environmental Protection Agency, Region 6	Accepted
Advisory Council on Historic Preservation	Declined
City of Aztec	Declined
City of Bloomfield	Declined
City of Farmington	Accepted
Hopi Tribe	Declined
Jicarilla Apache Nation	Declined
Kewa Pueblo	Declined
La Plata County, Colorado	Declined
Natural Resources Conservation Service	Declined
Navajo Nation Land Department	Declined
New Mexico Department of Game and Fish	Accepted
New Mexico Department of Transportation, Environmental Design Bureau	Declined
New Mexico Energy, Minerals and Natural Resources Department	Declined
New Mexico Energy, Minerals and Natural Resources Department, Forestry Division	Accepted
New Mexico Energy, Minerals and Natural Resources Department, Mining & Minerals Division	Declined
New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division	Declined
New Mexico Energy, Minerals and Natural Resources Department, Parks Division	Declined
New Mexico Environment Department	Declined
New Mexico Office of the State Engineer	Declined
New Mexico State Land Office, Surface Resources Division	Pending
New Mexico State Parks, Navajo Lake State Park	Declined
Navajo Nation – Ojo Encino Chapter House (Tri-Chapters)	Accepted
Navajo Nation – Counselor Chapter House (Tri-Chapters)	Accepted
Navajo Nation – Torreon/Star Lake Chapter House (Tri-Chapters)	Accepted
Pueblo of Acoma	Accepted
Pueblo of Cochiti	Declined
Pueblo of Isleta	Declined
Pueblo of Jemez	Declined
Pueblo of Laguna	Pending
Pueblo of San Felipe	Accepted
Pueblo of Sandia	Declined

Agency/Tribe Invited to be a Cooperating Agency	Status
Pueblo of Santa Ana	Declined
Pueblo of Zia	Declined
Pueblo of Zuni	Accepted
Rio Arriba County	Declined
San Juan County	Accepted
Sandoval County	Declined
San Joaquin Del Rio de Chama Land Grant (La Merced Del Pueblo de San Joaquin Del Rio de Chama)	Accepted
Southern Ute Indian Tribe	Declined
US Army Corps of Engineers, Durango Regulatory Office	Declined
US Department of Agriculture, Rural Utilities Services	Declined
US Department of the Interior, Bureau of Indian Affairs, Division of Real Estate Services	Declined
US Department of the Interior, Bureau of Indian Affairs, Navajo Region, Shiprock Agency	Declined
US Department of the Interior, Bureau of Indian Affairs, Southwest Region	Accepted
US Department of the Interior, Bureau of Indian Affairs, Southwest Region, Jicarilla Agency	Declined
US Department of the Interior, Bureau of Indian Affairs, Southwest Region, Southern Pueblos Agency	Declined
US Department of the Interior, Bureau of Indian Affairs, Southwest Region, Southern Ute Agency	Declined
US Department of the Interior, Fish and Wildlife Service	Accepted
US Department of the Interior, Geological Survey, New Mexico Water Science Center	Declined
US Department of the Interior, National Park Service, Aztec Ruins National Monument	Accepted
US Geological Survey-New Mexico Water Science Center	Accepted
Ute Mountain Ute Tribe	Declined
Village of Cuba	Declined
Western Area Power Association	Declined

Appendix P
List of Preparers

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Appendix P. List of Preparers

Name	Role/Responsibility
Bureau of Land Management Interdisciplinary Team	
Jillian Aragon	BLM Acting Project Manager, Public Affairs Specialist
Al Elser	BLM District Manager
Rick Fields	BLM Field Manager
Marcella Martinez	BLM Assistant Project Manager, Planning and Environmental Specialist
Ryan Joyner	Planning and Environmental Coordinator
Sharay Dixon	Air Resources
Jason Burgess-Conforti	Air Resources
Matt Dorsey	BLM GIS Specialist
Jeff Tafoya	BLM Natural Resources Lead, Air Resources, Climate Change, Forestry
Doug McKim	Wilderness and Wilderness Study Areas, Lands with Wilderness Characteristics, Recreation and Visitor Services, SDAs (Recreation, Wilderness areas)
Chris Wenman	Fluid Minerals, Noise Resources
Tony Gallegos	Solid Minerals, Geology, SDAs (Geology)
Dave Mankiewicz	Solid Minerals, Geology, SDAs (Geology)
Kim Adams	Cultural Resources
Erik Simpson	Cultural Resources
Geoff Haymes	BLM Section 106 Consultation Lead, Cultural Resources, National Historic Trails, SDAs (Cultural)
Lola Henio	BLM Tribal Liaison, Native American Tribal Interests and Uses, Environmental Justice
Monica Tilden	Lands and Realty
Michael Johnson	Social and Economic Uses
John Kendall	Fish and Wildlife, Special Status Species, Upland Vegetation, Riparian Areas and Wetlands, SDAs (Riparian, Wildlife, T&E species, Riparian), Water Resources
Sherrie Landon	Paleontological Resources, SDAs (Paleontology)
Stan Allison	Wilderness and Wilderness Study Areas, Visual Resources/Night Skies, SDAs (Wilderness areas)
Heather Perry	Noxious Weeds and Invasive Species, Upland Vegetation
Troy Salyers	Water Resources, COR
Cassandra Gould	Livestock Grazing
Nolan Craun	Livestock Grazing
Whitney Thomas	Air Resources, Water Resources, Soil Resources
Bureau of Indian Affairs Interdisciplinary Team	
Robert Begay	BIA Project Manager; Cultural Resources, Social and Economic Uses, Environmental Justice, National Historic Trails, Native American Tribal Interests and Use, Visual Resources/Night Skies
John Halliday	BIA Deputy Navajo Regional Director
Lester Tsosie	Superintendent, BIA Eastern Navajo Agency
George Padilla	Supervisory Environmental Scientist
Roderick Yazzie	BIA GIS Lead
Robert Babbitt	Lands and Realty
Lyle Ben	Geology, Minerals, Indian Trust Assets
Calvert Curley	Air Resources, Natural Resources
Jerry DeGroat	Lands and Realty
Effie Delmar	Livestock Grazing, Special Status Species, Upland Vegetation, Riparian Areas and Wetlands, Noxious Weeds and Invasive Species, Soil Resources
Maureen Joe	Social and Economic Uses, Environmental Justice

Name	Role/Responsibility
Rudy Keedah	Water Resources, Geology
Jordan Pina	Forestry, Fish and Wildlife, Recreation and Visitor Services
Federal Indian Minerals Office (FIMO)	
Maureen Joe	FIMO Project Advisor/Social and Economic Uses, Environmental Justice
Environmental Management and Planning Solutions, Inc. (EMPSi)	
Katie Patterson	Project Manager, Minerals, Geology
David Batts	Principal-in-Charge
Becky Boyle	Project Assistant
William Penner	BIA Project Facilitator/ Cultural Resources, Native American Tribal Interests and Uses
Theresa Ancell	BLM Project Facilitator/Visual Resources, Night Skies, Forestry
Marcia Rickey	GIS Lead
Jenna Jonker	GIS Specialist
Amy Cordle	Air Resources, Climate Change
Sean Cottle	Lands with Wilderness Characteristics, Wilderness and Wilderness Study Areas
Francis Craig	Geology, Minerals, Public Safety
Kevin Doyle	Paleontological Resources
Zoe Ghali	Livestock Grazing, Social and Economic Uses, Environmental Justice
Peter Gower	Noise Resources, Recreation and Visitor Services, National Historic Trails, Lands and Realty
Morgan Triger	Riparian Areas and Wetlands, Noxious Weeds and Invasive Species
Derek Holmgren	Upland Vegetation and Soils, Water Resources, Forestry, Visual Resources/Night Skies
Kate Krebs	Wilderness and Wilderness Study Areas, Specially Designated Areas
Molly McCarter	Visual Resources/Night Skies
Dan Morta	Fish and Wildlife, Special Status Species
Julie Remp	Fish and Wildlife, Special Status Species
Meredith Zaccherio	Upland Vegetation, Riparian Areas and Wetlands, Noxious Weeds and Invasive Species, Special Status Species
Ramboll	
Krish Vijayaraghavan	Air Resources, Climate Change

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