3.0 Affected Environment

3.1 Introduction

This chapter describes the environment that would be affected by the alternatives analyzed in this Environmental Impact Statement (EIS). The baseline information summarized in this chapter was obtained primarily from data, reports, and references provided by the Bureau of Land Management (BLM), the White River National Forest (WNRF), and the Grand Mesa, Uncompahgre, and Gunnison National Forest (GMUGNF), supplemented by information and references submitted by the cooperating agencies. The affected environment for each resource was delineated based on the area where potential environmental impacts are likely to result from the leasing decision and subsequent projected development.

In general, the descriptions of the affected environment focus on the land within the analysis area boundary shown in **Figure 1-1**. For resources such as soils and vegetation, the affected area was determined to be the physical location within the boundaries of the 65 previously issued leases. For other resources such as water, air quality, and socioeconomics, the description of the affected environment is more extensive (e.g., watersheds, airsheds, counties).

The specific aspects of each resource that are described in each section were selected because they have the potential to be affected by the proposed leasing decisions under consideration or the future development that is projected to occur following the leasing decisions. The affected environment descriptions provide a baseline for comparison of potential environmental consequences under each alternative analyzed in Chapter 4.0.

This page intentionally left blank

3.2 Air Quality

3.2.1 Regional Affected Environment

The USEPA, as directed by the CAA, has established NAAQS for criteria pollutants. Criteria pollutants are air contaminants that are commonly emitted from the majority of emissions sources and include carbon monoxide (CO), lead (Pb), sulfur dioxide (SO_2), particulate matter with an aerodynamic diameter smaller than 10 and 2.5 microns (PM_{10} and $PM_{2.5}$, respectively), ozone (O_3), and nitrogen dioxide (NO_2). Ozone is not directly emitted from any sources, but is formed in the atmosphere through chemical interactions of oxides of nitrogen (NO_X) and volatile organic compounds (VOCs) in the presence of sunlight and under certain meteorological conditions (NO_X and VOCs are known as ozone precursors). Exposure to air pollutant concentrations greater than those established by the NAAQS has been shown to have a detrimental impact on human health and the environment. The USEPA regularly reviews the NAAQS (every 5 years) to ensure that the latest science on health effects, risk assessment, and observable data such as hospital admissions are considered, and can revise any of the NAAQS if the data supports this decision. The current NAAQS levels are shown in **Table 3.2-1**. Ambient air quality standards must not be exceeded in areas where the general public has access.

The CAA has established two types of NAAQS:

Primary standards: Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.

Secondary standards: Secondary standards set limits to protect public welfare, including protection against decreased visibility, and damage to animals, crops, vegetation, and buildings.

In addition to the criteria pollutants, regulations also exist to control the release of hazardous air pollutants (HAPs). HAPs are chemicals known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or other adverse environmental effects. USEPA currently lists 187 compounds identified as hazardous air pollutants, some of which can be emitted from oil and gas development operations, such as benzene, toluene, and formaldehyde. There are no ambient air quality standards for HAPs, rather these emissions are regulated by the source type, or specific industrial sector responsible for the emissions.

The USEPA has delegated regulation of air quality to the State of Colorado (for approved State Implementation Plan (SIP) elements). The Colorado Department of Public Health and Environment (CDPHE), Air Pollution Control Division (APCD) administers Colorado's air quality control programs, and is responsible for enforcing the state's air pollution laws.

The Federal Land Policy and Management Act of 1976 (FLPMA) requires the BLM to ensure actions taken by the agency provide for compliance with federal, state, tribal, and local air quality standards and regulations. FLPMA further directs the Secretary of the Interior to take any action necessary to prevent unnecessary or undue degradation of the lands [Section 302 (b)], and to manage the public lands "in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values" [Section 102 (a)(8)].

Table 3.2-1 National Ambient Air Quality Standards

Pollutant (final rule citation)		Standard Type	Averaging Period	Level	Form
Carbon Monoxide [76 Federal Register (FR) 54294, August 31, 2011]		Primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, November 12, 2008]		Primary and Secondary	Rolling 3-month average	0.15 μg/m³	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, February 9, 2010] [61 FR 52852, October 8, 1996]		Primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		Primary and Secondary	Annual	53 ppb	Annual mean
Ozone [80 FR 65292, October 26, 2015]		Primary and Secondary	8-hour	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particulate Matter [73 FR 3086, January 15, 2013]	$PM_{2.5}$	Primary	Annual	12 μg/m³	Annual mean, averaged over 3 years
		Secondary	Annual	15 μg/m³	Annual mean, averaged over 3 years
		Primary and Secondary	24-hour	35 μg/m³	98th percentile, averaged over 3 years
	PM_{10}	Primary and Secondary	24-hour	150 μg/m³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, June 22, 2010] Colorado (State Only) [38 FR 25678, September 14, 1973]		Primary	1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Primary and Secondary	3-hour	267 ppb	Not to be exceeded in any 12-month period
		Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

μg/m³ = micrograms per cubic meter

ppb = parts per billion

ppm = parts per million

Source: National – 40 CFR 50, Colorado – 5 CCR 1001-14.

Prevention of Significant Deterioration

The CAA contains provisions for protection of air quality in areas that are meeting the ambient air quality standards. This is known as the prevention of significant deterioration (PSD) program. Under this program, areas of the country are designated as Class I or Class II. Class I areas are defined as areas of special, national, or regional natural, recreational, or historic value and thus receive special protection under the CAA. Class I areas include wilderness areas more than 5,000 acres in size and national parks more than 6,000 acres in size that were in existence in 1977. Sensitive Class II areas are usually afforded additional protection under state-specific rule making for one or more pollutants. This status distinguishes them from Class II areas which account for every other area of the country that is not explicitly designated as Class I or Sensitive Class II.

An area's class designation determines the maximum amount of additional air pollution, called an increment, which can be added beyond a baseline value emitted from new or modified "major" stationary sources of pollution. Increment consumption analysis falls under the PSD major sources permitting program, which is administered in Colorado by the Colorado Department of Public Health and Environment (CDPHE), Air Pollution Control Division (APCD). Only small amounts of pollutants can be added in Class I areas, while Class II areas permit moderate amounts of pollutants to be added.

The CAA also charges federal land managers with an "affirmative responsibility to protect the air quality related values (including visibility)" of Class I areas that they manage. Air quality related values are resources, as identified by the federal land manager, for one or more federal areas that may be adversely affected by a change in air quality. The resources may include visibility or specific scenic, cultural, physical, biological, ecological, or recreational resources identified by the Federal Land Manager (FLM) for a particular area (FLAG 2010).

Visibility

Visibility is a measure of not only how far one can see but how well one can see important characteristics of the landscape such as form, color, geologic features, and texture. Visibility impairment is caused by the scattering of light by gases and particles in the atmosphere. Some particles in the atmosphere result from man-made pollution, resulting in haze. A monitoring network was established by the Interagency Monitoring of Protected Visual Environments (IMPROVE) program to measure atmospheric particulate concentrations near Class I areas.

The CAA amendments of 1977 set a national goal of preventing future impairment of visibility and remedying any existing impairment of visibility in Class I areas that is caused by man-made pollution. The USEPA promulgated the Regional Haze Rule in order to meet this goal. The Regional Haze Rule requires states to develop air quality protection plans to reduce the pollution that causes visibility impairment in Class I areas, with a goal of achieving "natural" visibility levels within a 60-year period. The USEPA has provided guidance to help states estimate natural visibility for their Class I areas (USEPA 2003).

Hazardous Air Pollutants

Air pollutants that may cause chronic (long-term) or acute (short-term) harmful effects are classified as hazardous air pollutants (HAPs). CAA sections 111 and 112 establish mechanisms for controlling HAPs from stationary sources, and the USEPA is required to control emissions of 187 HAPs. Unlike criteria pollutants, the CAA does not establish ambient concentration standards for HAPs. However, the USEPA has promulgated National Emission Standards for Hazardous Air Pollutants (NESHAP) for 96 different source categories. While NESHAP applicability will depend on the type of source constructed, the following NESHAP regulations are likely to apply to facilities constructed in the CRVFO:

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

A list of NESHAP regulations can be found on the USEPA's web site: (http://www.epa.gov/ttn/atw/mactfnlalph.html).

New Source Performance Standards (NSPS)

CAA section 111 establishes mechanisms for controlling emissions of air pollutants from stationary sources. Section 111(b) provides authority for the USEPA to promulgate NSPS that apply only to new and modified sources. These standards are intended to promote use of the best air pollution control technologies, taking into account the cost of such technology and any other non-air quality, health, and environmental impact and energy requirements. The USEPA has promulgated NSPS for 94 different source categories. While NSPS applicability will depend on the type of source constructed, the following NSPS are likely to apply to facilities constructed in the CRVFO:

- NSPS Subpart JJJJ, Standards of Performance for Stationary Spark Ignition Internal Combustion Engines; and
- NSPS Subpart OOOO, Standards of Performance for Crude Oil and Natural gas Production, Transmission and Distribution.

Non-Road Diesel Engine Standards

EPA established federal standards for new non-road diesel engines that would include most oil and gas development drilling, completion and fracing engines. The 1998 non-road engine regulations were structured as a 3-tiered progression. Each tier involved a phase-in (by horsepower rating) over several years. Tier 1 standards were phased-in from 1996 to 2000. The more stringent Tier 2 standards took effect from 2001 to 2006, and yet more stringent Tier 3 standards phased-in from 2006 to 2008. The Tier 4 emission standards—phased-in from 2008 through 2015—introduce substantial reductions of NO_X (for engines above 56 kW) and PM (above 19 kW), as well as more stringent HC limits. For Tier 4 emissions standards, CO emission limits remain unchanged from the Tier 2-3 stage.

3.2.1.1 State

The USEPA has delegated to the State of Colorado the authority to enforce NAAQS and PSD increments and to issue air quality permits. The CAA requires states to submit State Implementation Plans (SIPs) to the USEPA that provide for the implementation, attainment, maintenance, and enforcement of the NAAQS. The CDPHE, APCD administers Colorado's air quality control programs and is responsible for enforcing the state's air pollution laws.

The Colorado Air Pollution Control Commission oversees the development and adoption of the state's air quality regulation program. The commission can set its own ambient air quality standards that are equal to or more stringent than the federal air quality standards. The state has adopted one additional standard (for SO_2) in addition to the federal standards, which is noted in **Table 3.2-1**. The APCD implements the air management programs adopted by the commission and enforces compliance with the NAAQS and PSD increments.

In February 2014, the State of Colorado adopted new regulations that will affect emissions from the oil and gas industry. These include Regulation 7, which contains extensive requirements to control emissions of ozone precursors and hydrocarbons from equipment associated with oil and gas development and production. In addition to extensive VOC reductions, Regulation 7 revisions also regulate methane emissions from the oil and gas industry. Colorado also adopted Regulation 6, which incorporates NSPS Subpart OOOO.

Other regulations potentially affecting oil and gas projects include Regulation 8, in which Colorado adopts federal air quality regulations for control of hazardous air pollutants. Reporting of HAPs is required under Regulation 3 if uncontrolled emissions are more than 250 pounds per year.

3.2.2 Existing Regional Air Quality

Air quality for any area is generally influenced by the amount of pollutants that are released within the vicinity and up wind of that area, and can be highly dependent upon the contaminants chemical and physical properties. Additionally, an area's topography or terrain (such as mountains and valleys) and weather (such as wind, temperature, air turbulence, air pressure, rainfall, and cloud cover) will have a direct bearing on how pollutants accumulate or disperse. Ambient air quality in the affected environment (i.e. compliance with the NAAQS) is demonstrated by monitoring for ground level atmospheric air pollutant concentrations. The APCD monitors ambient air quality at a number of locations throughout the state. Similarly, several Federal Land Managers (FLMs) like the BLM, Forest Service, and National Park Service (NPS), also monitor air quality for NAAQS and Air Quality Related Values (AQRVs) to meet organic act requirements. **Table 3.2-2** presents 4 years of monitoring data for criteria pollutants for each of the CRVFO counties (or adjacent/representative county monitors where no monitoring exists in the CRVFO). The values reported are consistent with the units and the form of the standard in **Table 3.2-1**, but where multiple monitors exist within a single county, the largest value for each pollutant is selected to compute the ozone design value (3-year average of the 4th highest 8-hour max), sum 3 consecutive years of data (if available) and divide by three.

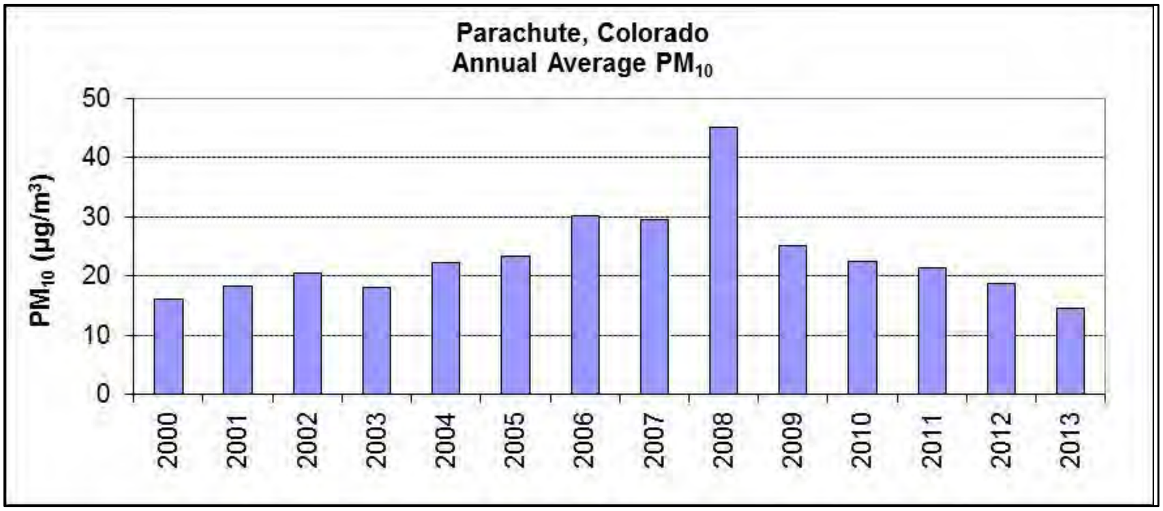
Table 3.2-2 Ambient Air Quality Monitoring Data[1]

County	Pollutant	Units	Averaging Time	2011	2012	2013	2014
Garfield	O_3	ppm	8-hour	0.076	0.073	0.065	0.062
Garfield	PM_{10}	$\mu g/m^3$	24-hour	73	46	34	42
Mesa	CO	ppm	1-hour	1.8	2	1.5	1.9
Mesa	CO	ppm	1-hour	1.1	2	1.5	1.9
Mesa	O_3	ppm	8-hour	0.074	0.071	0.067	0.062
Mesa	PM_{10}	$\mu g/m^3$	24-hour	54	64	53	43
Mesa	$PM_{2.5}$	$\mu g/m^3$	24-hour	23.1	24.3	40	27.3
Mesa	$PM_{2.5}$	$\mu g/m^3$	24-hour	7.1	7.3	8.9	7.8
Moffat	O_3	ppm	8-hour	0.06	0.066	0.065	0.062
Pitkin	O_3	ppm	8-hour	0.074	0.054	0.067	na
Pitkin	PM_{10}	$\mu g/m^3$	24-hour	46	55	35	37
Rio Blanco	NO_2	ppb	1-hour	23	19	24	14
Rio Blanco	O_3	ppm	8-hour	0.073	0.069	0.091	0.062
Rio Blanco	$PM_{2.5}$	$\mu g/m^3$	24-hour	21.5	33.4	26.4	15.8
Rio Blanco	$PM_{2.5}$	$\mu g/m^3$	24-hour	9.9	9.9	9.1	7.6
Routt	PM_{10}	$\mu g/m^3$	24-hour	79	93	77	81

Source: USEPA 2015a.

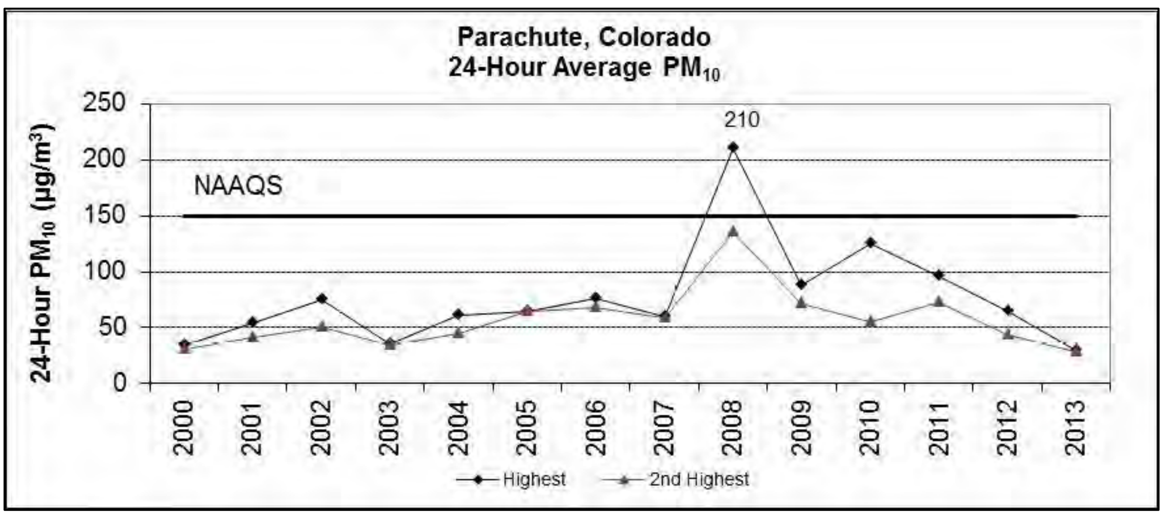
Although the analysis area is currently designated as attaining the NAAQS for all pollutants, several northwest Colorado area monitors have recorded exceedances of the current and new NAAQS for ozone and $PM_{2.5}$ (Mesa County) over the past several years (see Table above). Exceedances by themselves do not necessarily mean that the area will be designated as nonattainment (which would be determined by CDPHE and USEPA). The form of the NAAQS must be considered along with the monitored value. The form of the NAAQS for $PM_{2.5}$ and ozone require 3-year averages. Other NAAQS pollutants did not have any single-year exceedances for the last few years of monitoring.

Figure 3.2-1 presents the annual average PM_{10} concentrations measured at the Parachute site (since 2000). The highest average recorded PM_{10} occurred in 2008, and measurements have decreased since 2009. **Figure 3.2-2** presents the highest and second highest 24-hour average values measured at the Parachute site. Note that the NAAQS for 24 hour PM_{10} (150 µg/m^3) was exceeded for the overall maximum (1st high) concentration at the Parachute site in 2008. This exceedance was not a violation of the standard because the average number of annual exceedances over a 3-year consecutive period was not greater than one. **Figure 3.2-3** presents annual 8-hour average ozone values at Rifle, Colorado. Note the exceedance of the former NAAQS (75 ppb) that occurred in 2012. However, this exceedance was not a violation of the standard because that value is the overall maximum 8-hour average ozone concentration for year 2012 and the 4th highest values averaged over a 3-year consecutive period was not greater than the former NAAQS 75 ppb (see **Table 3.2-2** for 4th high 8-hour average monitored ozone concentration values to compare to new ozone NAAQS [70 ppb]).



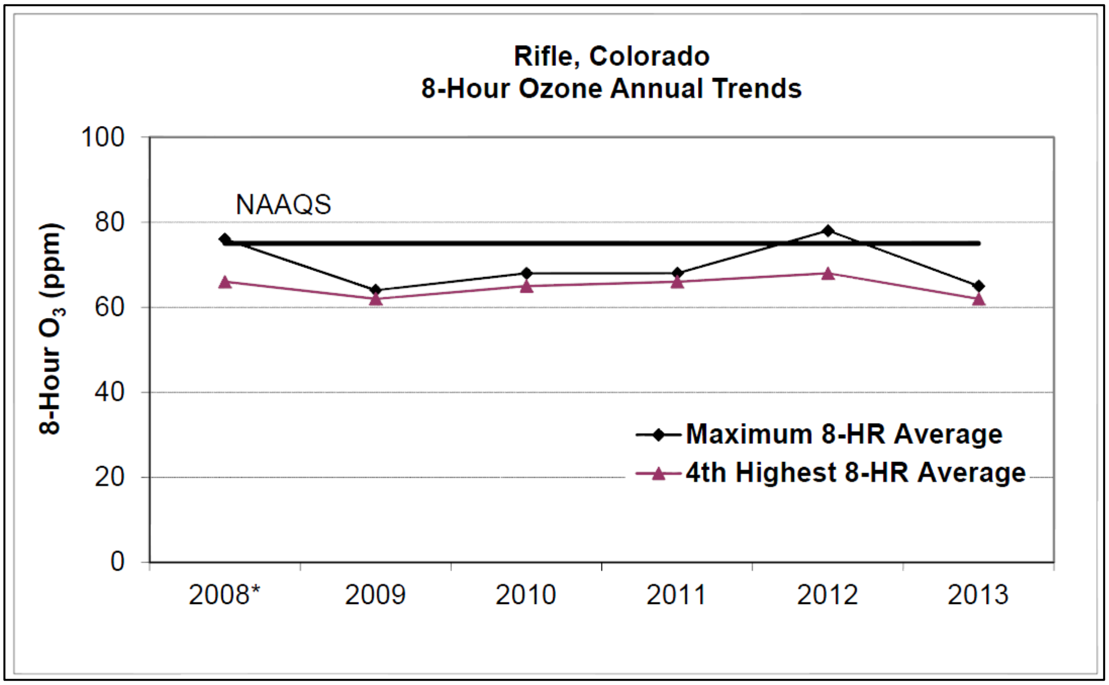
Source: ARS 2014.

Figure 3.2-1 24-hour Average PM_{10} at Parachute, Colorado AQS Site



Source: ARS 2014.

Figure 3.2-2 24-hour Average PM_{10} at Parachute, Colorado AQS



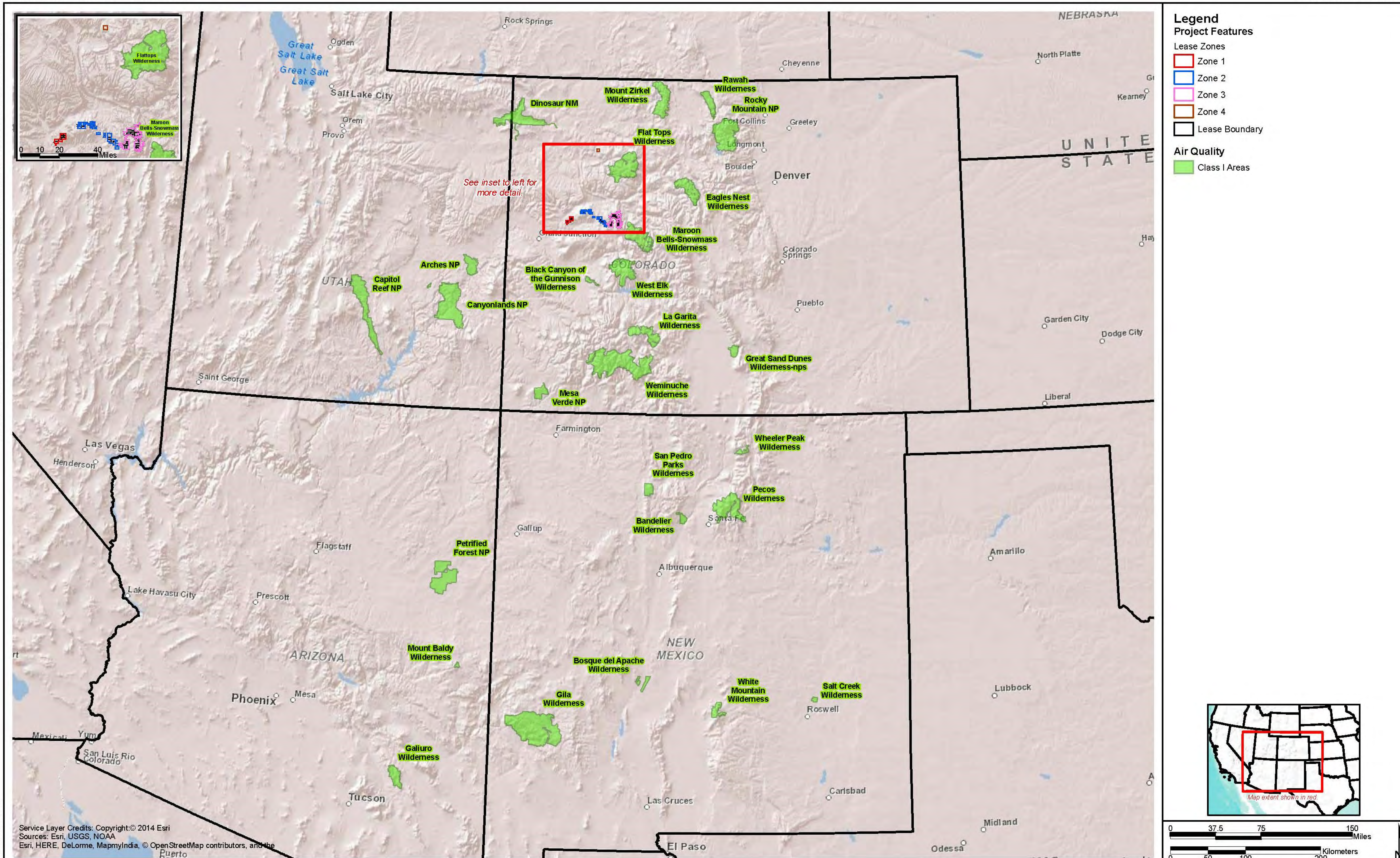
Source: ARS 2014.

Figure 3.2-3 Annual Average PM_{10} at Rifle, Colorado AQS Site

AQRVs are metrics for atmospheric related phenomena like visibility and pollutant deposition impacts that may adversely affect specific scenic, cultural, biological, physical, ecological, or recreational resources. Visibility changes can occur when an excessive amount of pollutants (mostly fine particles) scatter light such that the background scenery becomes hazy. Atmospheric deposition can cause excess nutrient loading in native soils and acidification of the landscape, which can lead to declining buffering capacity changes in sensitive stream and lake water chemistry (commonly referred to as acid neutralization change [ANC]). Air pollutants can be deposited by wet deposition (precipitation) and dry deposition (gravitational settling). The chemical components of wet deposition include sulfate (SO_4), nitrate (NO_3), and ammonium (NH_4) ions; the chemical components of dry deposition can include sulfate, sulfur dioxide (SO_2), nitrogen oxides (NO_X), nitrate, ammonium, and nitric acid (HNO_3). A recent 2014 NPS Study suggests that the critical nitrogen load value for high elevation surface water in all natural areas of Colorado is 2.3 kg/ha-yr. The NPS *Technical Guidance on Assessing Impacts on Air Quality in NEPA and Planning Documents* suggests that critical sulfur load values above 3 kg/ha-yr may result in moderate impacts. AQRVs are important to FLMs (landscape nutrient loading) and congressionally mandated goals (i.e. regional haze). Class I areas are generally pristine landscapes such as national parks, national forests, and wilderness areas that are specifically provided the highest levels of air quality protection under the CAA. Sensitive Class II areas are usually afforded additional protection under state specific rule making for one or more pollutants. This status elevates them above Class II areas which account for every other area of the country that is not explicitly designated as Class I or Sensitive Class II.

The WRNF is surrounded by Class I/sensitive Class II areas on the northern, eastern and southern Field Office boundaries and these areas are within or intersect the analysis area: Flat Tops Wilderness (Class I area-USFS), Eagles Nest Wilderness (Class I area-USFS) and Maroon Bells – Snowmass Wilderness (Class I area-USFS) (**Figure 3.2-4**).

This page intentionally left blank



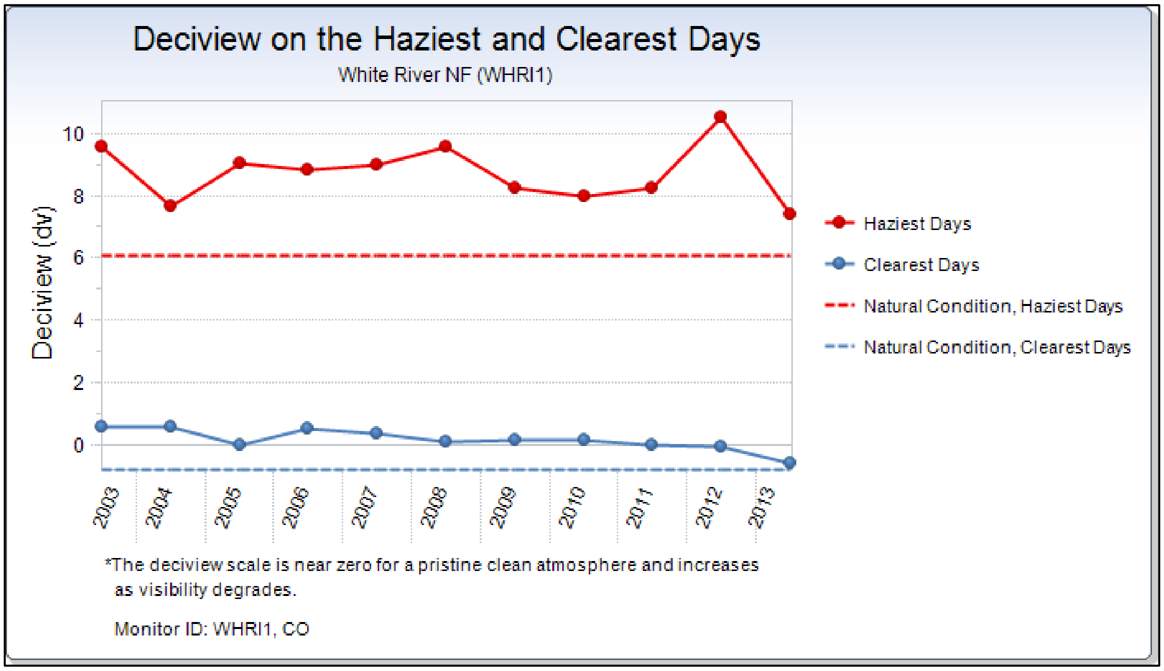
Y:\GIS\Projects\BLM_WhiteRiver_OG_EIS_60332451\FIGs\DOC1_PDEIS\FIG_3_2_4_ClassI_Air_Quality.mxd

Date: 9/17/2015

Figure 3.2-4 Class I Areas Surrounding the WRNF

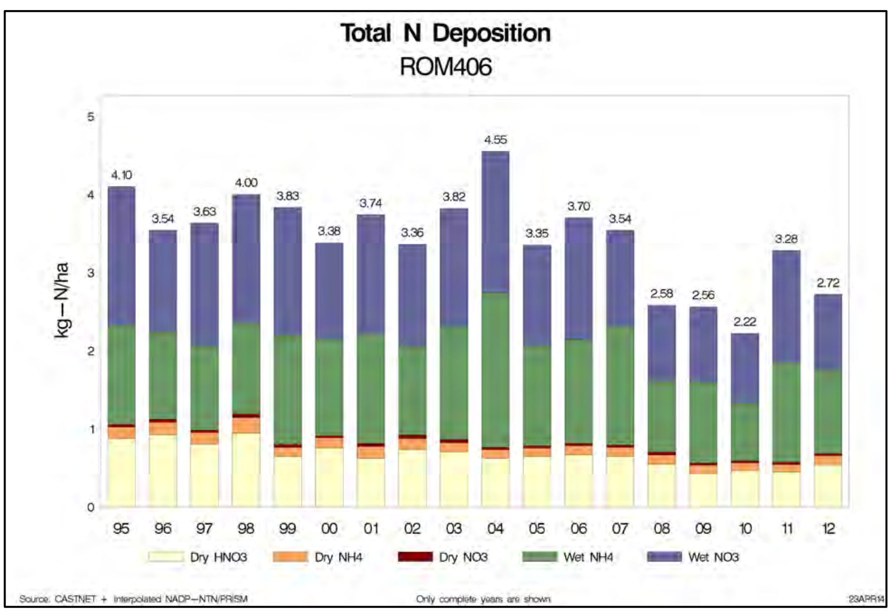
This page intentionally left blank

Figure 3.2-5 provides current trend data for visibility at White River National Forest. **Figures 3.2-6** and **3.2-7** provide deposition information at Rocky Mountain National Park. In general, trends with a negative slope indicate better atmospheric conditions for each potentially affected area.



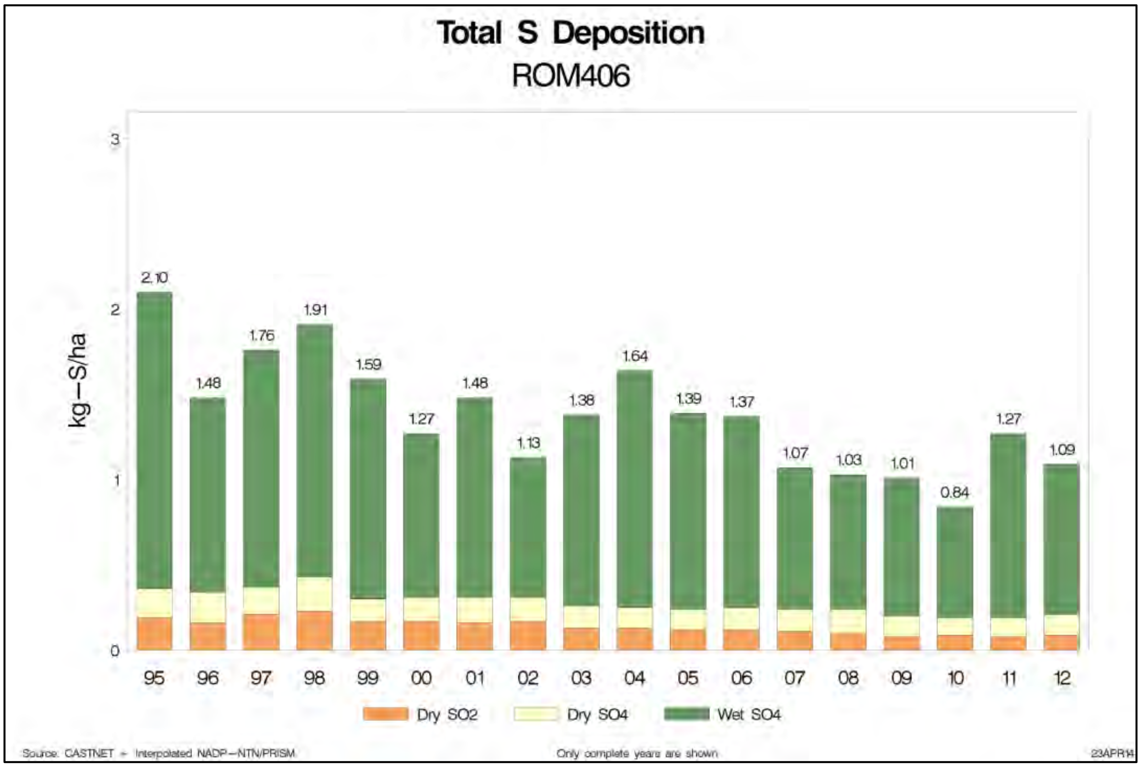
Source: FED 2015.

Figure 3.2-5 AQRV Visibility Data for White River National Forest



Source: USEPA 2015d.

Figure 3.2-6 AQRV Nitrogen Deposition Data for Rocky Mountain National Park



Source: USEPA 2015d.

Figure 3.2-7 AQRV Sulfur Deposition Data for Rocky Mountain National Park

HAPs are pollutants of concern since they are suspected or known to cause cancer or other serious health problems. The USEPA has designated approximately 187 compounds as HAPs including benzene, toluene, ethyl-benzene and xylenes (also known as BTEX compounds). Air toxics originate from human-made sources, including mobile sources (cars, trucks, buses, etc.), stationary sources (factories, refineries, power plants), as well as indoor sources (some building materials and cleaning solvents). Some air toxics also are released from natural sources such as volcanic eruptions and forest fires (USEPA 2015b).

Of most relevance for this EIS, HAPs can be emitted by natural gas wells and production equipment. Benzene emissions have been tracked in Garfield County and they were decreasing prior to 2005, but sources related to oil and gas activities have shown increasing trends (Garfield 2015). Colborn et al. (2014) found that for a sampling site located in Garfield County where residences and gas wells co-exist, the highest concentrations of non-methane hydrocarbons (NMHCs) occurred during the initial drilling phase and did not increase during hydraulic fracturing. Many NMHCs have multiple health effects, including 30 compounds that affect the endocrine system, which is susceptible to chemical impacts at very low concentrations. The authors also found that concentrations of selected polycyclic aromatic hydrocarbons (PAHs) were at greater levels than those considered by urban studies that found children prenatally exposed to PAHs had lower developmental and IQ scores. McKenzie et al. (2012) estimated health risks attributable to exposure to air emissions from a natural gas development project in Garfield County, Colorado. McKenzie et al. found that residents living less than 0.5 mile from wells are at greater risk for health effects from natural gas development than are residents living at more than 0.5 mile from wells.

Ambient studies in Garfield County have found that toluene and xylene concentrations measured in grab air samples averaged 105 and 138 μg/m^3, with maximum concentrations reaching 540 and 1,500 μg/m^3, respectively. Benzene concentrations averaged 32 μg/m^3, reaching a maximum of 180 μg/m^3 (UCDenver 2015). **Table 3.2-3** shows measured data for selected HAPs for a monitoring site located in Rifle Colorado. The 1-hour HAP concentrations can be compared to acute Reference Exposure Levels (RELs) for benzene (approximately 1,300 μg/m^3) and formaldehyde (approximately 55 μg/m^3). RELs are defined as concentrations at or below which no adverse health effects are expected. No REL is available for n-hexane; instead, the available Immediately Dangerous to Life or Health divided by 10 (IDLH/10) values is used which for n-hexane is approximately 390,000 μg/m^3. These IDLH values were determined by the National Institute for Occupational Safety and Health (NIOSH) and were obtained from USEPA's Air Toxics Database (USEPA 2011). These values approximate pollutant concentrations likely to produce mild effects during 1-hour exposures.

For long-term maximum potential exposure to HAPs the values in **Table 3.2-3** are compared to Reference Concentrations for Chronic Inhalation (RfCs) for benzene (approximately 30 μg/m^3), formaldehyde (approximately 9.8 μg/m^3) and n-hexane (approximately 700 μg/m^3). An RfC is defined by USEPA as the daily inhalation concentration at which no long-term adverse health effects are expected. RfCs exist for both non-carcinogenic and carcinogenic effects on human health (USEPA 2012).

Table 3.2-3 Selected HAPs Monitoring Data for 2013

Monitoring Station Information	Pollutant	Background Monitored Concentrations (μg/m^3)		Acute REL[1] (μg/m^3)	Non-Carcinogenic Chronic RfC[2] (μg/m^3)
		1-Hour	Annual Average		
Garfield County, Colorado (Rifle, Colorado). Monitor ID: 08-045-0007. 1-hour value is maximum for all reported concentrations in year 2013 dataset. Annual average value is average of all values in the year 2013 dataset.	Benzene	28.75	9.11	1,300	30
	Formaldehyde	4.37	1.38	55	9.8
	n-Hexane	80.01	20.46	390,000	700

[1] Air Toxic Acute Reference Exposure Levels.

[2] Air Toxic Non-Carcinogenic Chronic Reference Concentrations.

Source: USEPA 2015a, 2012, 2011.

3.2.3 Model-Predicted Existing Regional Air Quality

As part of the Comprehensive Air Resource Protection Protocol (CARPP), the BLM is conducting modeling analyses and developing tools for estimating the air quality and AQRV impacts associated with projected BLM-authorized mineral development activities in Colorado. The BLM has committed to the analysis of air quality and AQRV impacts through a unified regional air quality modeling study known as the Colorado Air Resource Management Modeling Study (CARMMS 2015). As part of the CARMMS modeling, a base case simulation representative of year 2008 conditions was performed in order to estimate predicted air quality changes from a base year (2008) to a future year. This section provides an overview of the base case modeling results.

Table 3.2-4 provides the ozone design values centered on the 2008 base year for selected monitors within Colorado from the CARMMS study. The values highlighted in yellow are design values that exceed the former ozone NAAQS 75 ppb (former ozone NAAQS used for baseline year 2008 analysis). These design values have been calculated following USEPA's modeling guidance (USEPA 2007) as implemented in USEPA's Modeled Attainment Test Software (MATS; Abt 2012). All counties with design values exceeding the ozone NAAQS occur along the Colorado Front Range, which is consistent with the current designation of portions of this area as nonattainment for the former 8-hour ozone standard.

Table 3.2-4 Base Case Ozone Design Values

Monitor Name	Latitude	Longitude	State	County	Ozone Design Value
CO_Adams_3001	39.8381	-104.9498	Colorado	Adams	71.5
CO_Boulder_0011	39.9572	-105.2385	Colorado	Boulder	77.3
CO_Denver_0014	39.7518	-105.0307	Colorado	Denver	70.3
CO_Douglas_0004	39.5345	-105.0704	Colorado	Douglas	78.3
CO_El Paso_0013	38.9583	-104.8172	Colorado	El Paso	68.0
CO_El Paso_0016	38.8531	-104.9013	Colorado	El Paso	70.3
CO_Jefferson_0002	39.8003	-105.1000	Colorado	Jefferson	75.0
CO_Jefferson_0005	39.6388	-105.1395	Colorado	Jefferson	74.3
CO_Jefferson_0006	39.9128	-105.1886	Colorado	Jefferson	82.0
CO_Jefferson_0011	39.7437	-105.1780	Colorado	Jefferson	76.3
CO_La Plata_1004	37.3039	-107.4842	Colorado	La Plata	70.0
CO_La Plata_7001	37.1368	-107.6286	Colorado	La Plata	66.0
CO_La Plata_7003	37.1026	-107.8702	Colorado	La Plata	67.0
CO_Larimer_0007	40.2772	-105.5450	Colorado	Larimer	74.3
CO_Larimer_0011	40.5925	-105.1411	Colorado	Larimer	78.0
CO_Larimer_1004	40.5775	-105.0789	Colorado	Larimer	67.3
CO_Montezuma_0101	37.1983	-108.4903	Colorado	Montezuma	69.3
CO_Weld_0009	40.3864	-104.7374	Colorado	Weld	72.7

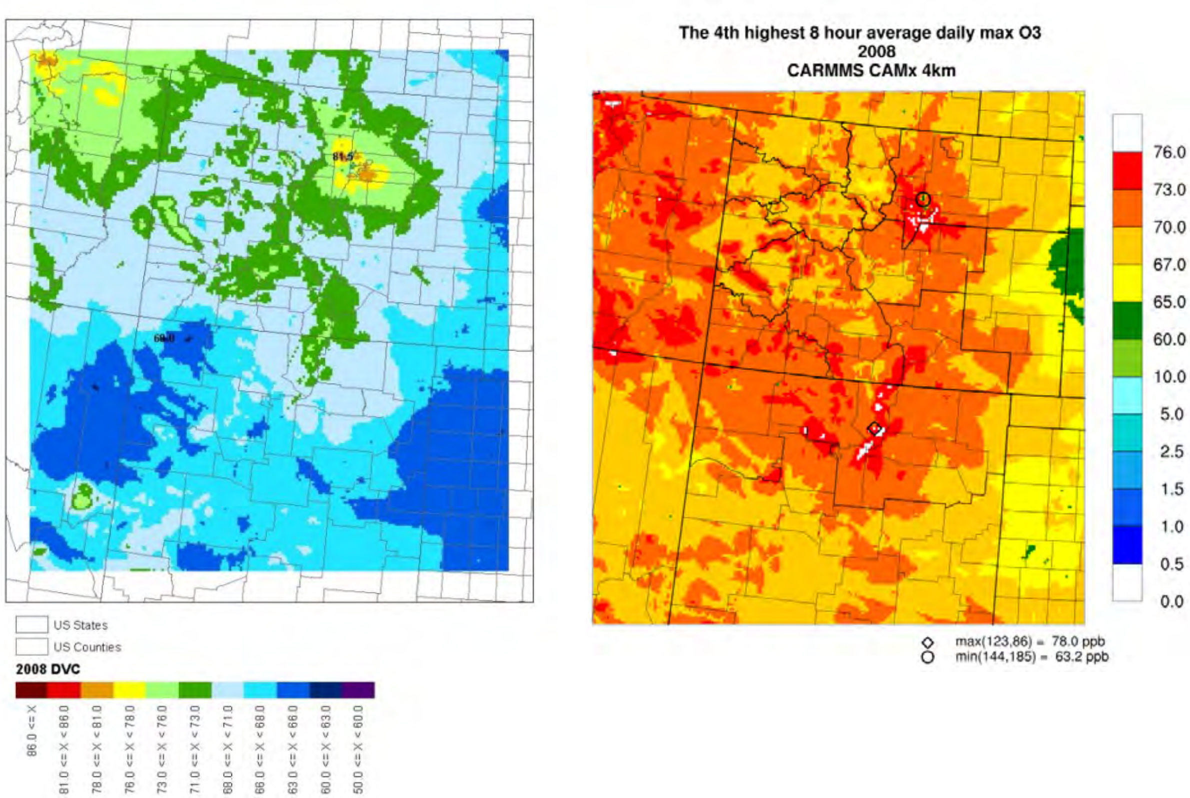
Source: CARMMS 2015.

Figure 3.2-8 presents the base case ozone concentrations predicted by the CARMMS modeling using two methods of evaluating the results: ozone design values as calculated by MATS (shown on the left) and year 2008 model-predicted concentrations (which is a format most comparable to the NAAQS when evaluating a single year of data). Generally the highest concentrations are observed along the Colorado Front range with maximum concentrations ranging between 78 to 81 ppb.

Figure 3.2-9 provides model-predicted $PM_{2.5}$ concentrations in two forms: the 8^{th} highest 24-hour $PM_{2.5}$ concentrations and the annual average $PM_{2.5}$ concentrations. In general, the largest concentrations in Colorado are observed along the Colorado Front Range with values that can exceed 35 $\mu g/m^3$ for the 8^{th} highest daily concentrations and 20 $\mu g/m^3$ for the annual average concentrations. However, the maximum domain-wide concentrations are located in southern New Mexico.

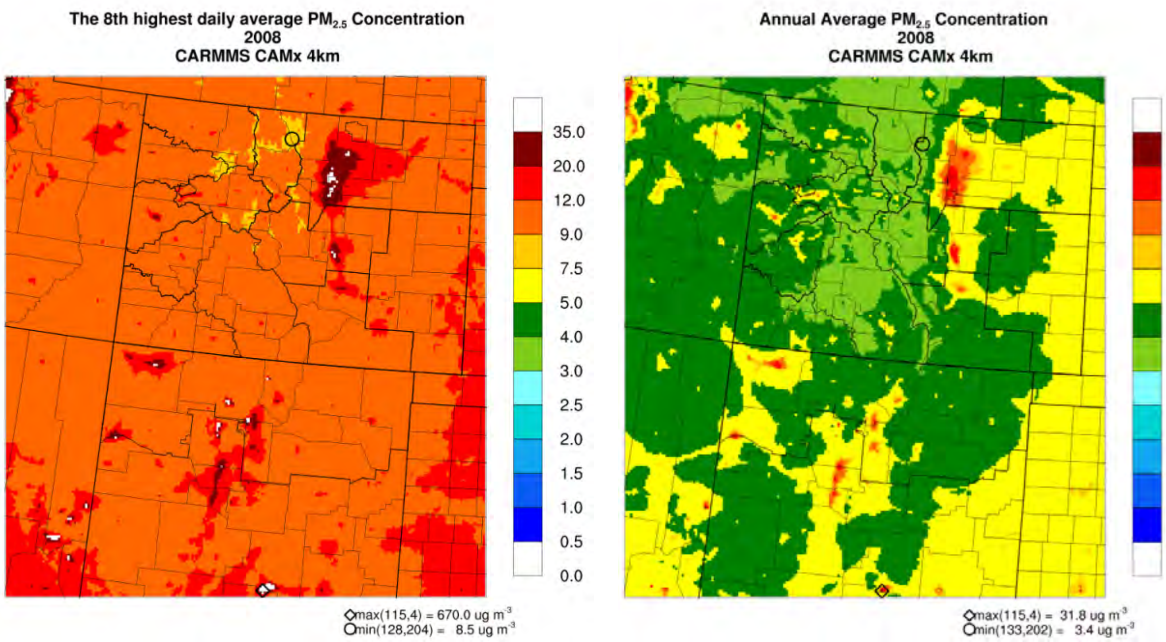
The CARMMS modeling also estimates AQRV impacts, namely visibility and deposition. **Table 3.2-5** provides estimates of the 20 percent worst and 20 percent best cumulative visibility days at Class I areas for the 2008 base case.

Table 3.2-6 provides model-predicted estimates of the total annual average and maximum nitrogen and sulfur deposition at Class I areas for the 2008 base case. While there are many areas that in 2008 have model-predicted nitrogen deposition that exceeds the NPS recommended critical loads, sulfur deposition in all areas is below the recommended sulfur critical load.



Source: CARMMS 2015.

Figure 3.2-8 Design Values (left) and 4th highest daily maximum 8-hour Ozone Concentrations (right) for the 2008 Base Case



Source: CARMMS 2015.

Figure 3.2-9 Eighth highest 24-hour (left) and annual average (right) $PM_{2.5}$ concentrations for the 2008 Base Case

Table 3.2-5 Cumulative Visibility for Worst 20% and Best 20% Visibility Days at Class I Areas for the 2008 Base Case

Class I Name	State	IMPROVE Site	Worst 20% Visibility	Best 20% Visibility
Arches National Park	UT	CANY1	11.02	2.86
Mount Baldy Wilderness	AZ	BALD1	11.10	2.86
Bandelier National Monument	NM	BAND1	11.33	4.01
Black Canyon of the Gunnison National Monument	CO	WEMI1	9.95	2.25
Bosque del Apache	NM	BOAP1	12.72	5.50
Canyonlands National Park	UT	CANY1	12.49	4.54
Capitol Reef National Park	UT	CAPI1	12.92	3.33
Eagles Nest Wilderness	CO	WHRI1	8.68	0.69
Flat Tops Wilderness	CO	WHRI1	8.68	0.69
Galiuro Wilderness[1]	AZ	CHIR1	11.58	2.58
Gila Wilderness	NM	GICL1	11.58	2.58
Great Sand Dunes National Monument	CO	GRSA1	10.90	3.58
La Garita Wilderness	CO	WEMI1	9.95	2.25
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.68	0.69
Mesa Verde National Park	CO	MEVE1	11.20	3.12
Mount Zirkel Wilderness	CO	MOZI1	9.36	0.95
Pecos Wilderness[2]	NM	BAND1	11.33	4.54
Petrified Forest National Park	AZ	PEFO1	12.49	4.01
Rawah Wilderness	CO	MOZI1	9.36	0.95
Rocky Mountain National Park	CO	ROMO1	12.04	1.91
Salt Creek	NM	SACR1	16.87	6.81
San Pedro Parks Wilderness	NM	SAPE1	9.43	1.28
West Elk Wilderness	CO	WHRI1	8.68	0.69
Weminuche Wilderness	CO	WEMI1	9.95	2.25
Wheeler Peak Wilderness[2]	NM	BAND1	11.33	4.01
White Mountain Wilderness	NM	WHIT1	12.92	3.33

Source: CARMMS 2015.

Table 3.2-6 Total Annual Nitrogen and Sulfur Deposition at Class I Areas for the 2008 Base Case

Class I Area	Nitrogen Deposition Maximum (kg N/ha/yr)	Nitrogen Deposition Average (kg N/ha/yr)	Sulfur Deposition Maximum (kg S/ha/yr)	Sulfur Deposition Average (kg S/ha/yr)
Arches National Park	2.20	1.81	0.36	0.33
Bandelier New Mexico	9.00	2.96	1.12	0.71
Black Canyon National Park	2.99	2.57	0.62	0.53
Bosque del Apache Wilderness Area	5.08	2.46	0.41	0.36
Canyonlands National Park	2.31	1.77	0.60	0.35
Capitol Reef National Park	3.37	1.90	0.55	0.33
Eagles Nest Wilderness Area	3.59	2.94	1.56	1.10
Flat Tops Wilderness Area	3.71	3.09	1.72	1.33
Galiuro Wilderness Area	2.97	2.83	1.12	1.02
Gila Wilderness Area	2.69	1.68	1.61	0.72
Great Sand Dunes National Monument	2.70	1.95	0.94	0.56
La Garita Wilderness Area	2.75	2.11	1.25	0.88
Maroon Bells-Snowmass	3.81	2.94	1.86	1.33
Mesa Verde National Park	3.14	2.76	0.91	0.80
Mount Baldy Wilderness Area	3.24	2.69	2.06	1.52
Mount Zirkel Wilderness Area	5.13	3.95	2.34	1.73
Pecos Wilderness Area	3.95	2.99	1.95	1.30
Petrified Forest National Park	2.66	2.16	0.80	0.68
Rawah Wilderness Area	4.07	3.27	1.77	1.29
Rocky Mountain National Park	4.49	3.50	1.91	1.35
Salt Creek Wilderness Area	8.21	5.39	0.73	0.66
San Pedro Parks Wilderness Area	3.36	2.93	1.61	1.24
Weminuche Wilderness Area	3.80	2.84	2.06	1.36
West Elk Wilderness Area	3.34	2.63	1.48	1.01
Wheeler Peak Wilderness Area	4.11	3.44	2.23	1.66
White Mountain Wilderness Area	3.73	2.85	1.85	1.11

Source: CARMMS 2015.

3.2.4 Analysis Area County Oil and Gas Production

Table 3.2-7 below shows the current oil and gas production statistics on a per county basis (well counts and production numbers are for both federal and fee minerals) for the counties containing the previously issued oil and gas leases and nearby counties: Garfield, Mesa, Moffat, Rio Blanco and Routt. The oil and gas data is from the Colorado Oil and Gas Conservation Commission (COGCC) database and is provided to convey the current level of intensity for oil and gas development within the vicinity of the analysis area.

Table 3.2-7 Analysis Area County Annual Production Data (2014)

County	Year	No. Producing wells	Oil Produced (barrels)	Gas Produced (MCF)	Water Produced (barrels)
Garfield	2014	12,693	2,035,678	605,612,719	38,733,797
Mesa	2014	1,849	65,522	36,389,860	1,917,343
Moffat	2014	770	387,714	16,110,261	5,584,878
Rio Blanco	2014	4,164	4,741,767	81,222,356	113,632,434
Routt	2014	46	58,064	149,068	1,580

Source: COGCC 2015.

3.2.5 National Emissions Inventory Data (2011)

As previously stated, air quality is generally a function of air pollutants emissions loading within any particular region. The National Emissions Inventory provides a comprehensive estimate of air emissions of both criteria and hazardous air pollutants from multiple air emission sources such as agriculture, biogenics, wild and prescribed fires, fuel combustion, industrial processes and others. With respect to the counties in the area of interest (Eagle, Garfield, Mesa, Pitkin, Rio Blanco and Routt in west and northwest Colorado), the emissions inventories in **Table 3.2-8** are provided to describe the affected environment in terms of current cumulative emissions intensities in tons per year. **Table 3.2-8** also shows the Colorado emission totals to provide some context of the magnitude of emissions for the counties in the area of interest.

3.2.6 Oil and Gas Emission Emissions Inventory Data (2011)

The emissions from the Colorado federal oil and gas sector estimated for the CARMMS are presented in **Table 3.2-9**. The table provides the federal oil and gas emissions for the year 2011 for CRVFO (outside of the Roan Plateau Planning Area (RPPA), as well as for those Planning Areas located in Northwestern Colorado, and all of Colorado.

Table 3.2-8 National Emissions Inventory Data

County	NO_x	CO	SO_2	PM_{10} Primary	$PM_{2.5}$ Primary	VOC	NH_3	CO_2	CH_4	N_2O	HAPs (VOC)
Eagle	3,412.4	21,055.6	68.4	3,075.4	1,087.6	18,568.5	386.2	557,774.6	303.7	16.5	2,066.4
Moffat	15,532.5	15,178.7	3,977.7	5,242.6	1,350.6	41,923.3	730.0	107,435.8	58.7	5.2	7,180.2
Garfield	16,412.9	29,787.7	186.8	4,170.1	1,209.8	118,709.0	369.0	569,714.4	133.7	18.8	7,569.7
Mesa	7,412.4	36,911.8	108.8	4,351.9	1,416.1	49,868.0	1,046.9	913,305.4	231.7	43.1	6,298.7
Pitkin	834.3	7,107.2	18.1	573.3	242.4	11,399.6	74.7	159,096.2	56.0	6.6	1,056.3
Rio Blanco	5,027.5	11,556.6	338.7	5,090.8	1,128.2	57,808.8	408.4	71,277.6	19.9	2.7	5,589.6
Routt	7,951.0	20,204.9	2,243.0	7,855.8	2,125.6	29,164.8	609.7	303,702.4	526.2	8.5	2,752.5
Total Colorado	**337,092.6**	**1,575,920.5**	**55,718.3**	**329,190.3**	**101,828.4**	**1,420,144.6**	**79,360.6**	**36,101,024.5**	**20,317.8**	**1,377.6**	**194,894.9**

Source: USEPA 2015c.

Table 3.2-9 CARMMS Federal Oil and Gas Emissions Data (2011)

Planning Area	NO_x	VOC	CO	PM_{10}	$PM_{2.5}$	SO_2	Benzene	Toluene	Ethylbenzene	Xylenes	Formaldahyde	n-hexane	CO_2	CH_4	N_2O
CRVFO (not including the RPPA)	1,035.98	2,596.16	734.23	200.37	52.53	6.87	66.58	72.59	4.23	75.96	40.94	156.15	332,461.58	9,914.12	4.95
Total Northwest Colorado[1]	6,887.52	11,117.10	5,206.61	875.23	330.44	291.13	293.08	349.68	19.94	312.67	215.26	551.39	2,120,818.26	50,026.24	33.30
Total All Colorado	8,394.53	13,007.28	7,339.87	998.91	378.72	293.27	300.59	358.78	23.51	323.08	224.45	580.38	2,321,470.63	57,648.49	36.13

[1] Northwest Colorado Totals include the following Planning areas: CRVFO, Roan Plateau Planning Area, GJFO, Little Snake Field Office (LSFO), and WRFO. The Northwest emissions include those from the Piceance Basin Area.

Source: CARMMS 2015.

3.2.7 Greenhouse Gases and Climate Change

There is broad scientific consensus that humans are changing the chemical composition of Earth's atmosphere. Activities such as fossil fuel combustion, deforestation, and other changes in land use are resulting in the accumulation of trace greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and several industrial gases in the Earth's atmosphere. An increase in GHG emissions results in an increase in the earth's average surface temperature, primarily by trapping and thus decreasing the amount of heat energy radiated by the Earth back into space. The phenomenon is commonly referred to as global warming. Global warming is expected in turn, to affect weather patterns, average sea level, ocean acidification, chemical reaction rates, and precipitation rates, which is collectively referred to as climate change.

While GHGs do not have applicable ambient standards or emission limits under the major environmental regulatory programs, several anthropogenic activities contribute to climate change, including emissions of GHGs from fossil fuel development and activities using combustion engines. The Intergovernmental Panel on Climate Change (IPCC) reports that since 1750, the largest contribution to total radiative forcing is caused by the increase in atmospheric concentration of CO_2 (IPCC 2013). In addition, "the atmospheric concentrations of CO_2, CH_4, and N_2O have increased to unprecedented levels in at least the last 800,000 years. CO_2 concentrations have increased by 40 percent since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land use change emissions" (IPCC 2013).

According to the National Climate Assessment (Melillo et al. 2014), U.S. average temperature also have increased by 1.3°F to 1.9°F since record keeping began in 1895, and most of this increase has occurred since 1970.

While the earth has had many episodes of warming and cooling in the past, the IPCC recently concluded that the recent warming of the climate system is very unique when compared to those past episodes. Additionally, most of the observed increase in globally average temperatures since the mid-20th century is due to the observed increase in anthropogenic GHG concentrations (IPCC 2013).

Table 3.2-10 provides a summary of the Colorado GHG emissions in million metric tons of CO_2 equivalents ($MMTCO_2e$) as estimated with the USEPA's State Inventory Tool by the Colorado Department of Public Health and Environment (CDPHE). The table provides a comparison of emissions by sector and shows that most GHG emissions in Colorado come from the electric power, transportation, and residential/commercial/industrial fuel use sectors in decreasing order.

Table 3.2-10 Colorado GHG Emissions by Emissions Sector (2010)

Sector	GHG Emissions ($MMTCO_2e$)
Electric Power	40
Transportation	30
Residential, Commercial & Industrial Fuel Use	27
Natural Gas and Oil Systems	10
Agriculture	9
Coal Mining & Abandoned Mines	8
Industrial Processes	4
Waste Management	3
Total	**130**

Source: CDPHE 2014.

Table 3.2-11 provides a summary of the energy-related CO_2 emissions as reported by the U.S. Energy Information Administration (USEIA) in their 2014 Annual Energy Outlook. The table provides a comparison of CO_2 emissions by fuel type for both the entire United States and the Mountain Region. The USEIA defines the Mountain Region as the States of Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Utah, and Wyoming. The table shows that in the entire U.S., petroleum sources are the largest contributor to CO_2 followed by coal, while in the Mountain Region the largest contributor to CO_2 emissions is coal followed by petroleum.

Table 3.2-11 Energy Related CO_2 Emissions by Fuel Type (2011)

Fuel Type	United States ($MMTCO_2$)	Mountain Region ($MMTCO_2$)
Petroleum[1]	2,304.0	156.8
Natural Gas	1,306.0	96.6
Coal	1,876.0	206.5
Other[2]	12.0	0.0
Total	**5,498.0**	**459.9**

[1] This includes carbon dioxide from international bunker fuels, both civilian and military, which are excluded from the accounting of carbon dioxide emissions under the United Nations convention. From 1990 through 2012, international bunker fuels accounted for 90 to 126 million metric tons annually.

[2] Includes emissions from geothermal power and nonbiogenic emissions from municipal waste.

Source: USEIA 2015.

3.3 Geological, Mineral, and Paleontological Resources

3.3.1 Regulatory Framework

3.3.1.1 Minerals

Federally owned minerals in the public domain are classified into specific categories that only apply to minerals in the federal mineral estate. Within legal constraints, publicly owned minerals are available for exploration, development, and production, while subject to existing regulations, standard terms and conditions, and stipulations. The classifications listed below are based on Acts passed by the U.S. Congress.

- Leasable minerals (which include fluid minerals such as oil and gas, geothermal resources and associated by-products, oil shale, native asphalt, oil impregnated sands as well as solid minerals such as coal and phosphates) are associated with the following laws; Mineral Leasing Act of 1920, as amended by the Federal Onshore Oil and Gas Leasing Act of 1987; Mineral Leasing Act for Acquired Lands of 1947, as amended; and the Geothermal Steam Act of 1970, as amended. Leasable minerals are acquired by applying to the federal government for a lease to explore and develop the minerals (see Chapter 1.0, **Table 1-3**, Major Federal Laws and Regulations Related to Oil and Gas Leasing).
- Locatable minerals (including precious and base metallic ores and nonmetallic minerals such as bentonite, gypsum, chemical grade limestone, and chemical grade silica sand) are acquired under the General Mining Law of 1872, as amended and the Surface Use and Occupancy Act of July 23, 1955 (American Geological Institute 1997).
- Salable minerals (common mineral materials such as sand, gravel, roadbed, ballast, and common clay that are sold by contract with the federal government) are regulated under the Mineral Material Act of July 23, 1947, as amended, and the Surface Use and Occupancy Act of July 23, 1955 (American Geological Institute 1997).

Other applicable guidance related to oil and gas leasing includes the following:

- WRNF Land and Resource Management Plan (LRMP) identification of areas subject to no surface occupancy, controlled surface use, or timing limitations restrictions and stipulations that could affect geological and mineral resources.
- Forest Service Manual (FSM) 2820 (guidance on mineral leasing operations National Forest System [NFS] lands).
- FSM 2860 (guidance on mineral prospecting and collecting operations on NFS lands, including geophysical activities).
- BLM Colorado Standard Oil and Gas Lease Stipulations.

3.3.1.2 Geological Hazards

Various federal and state regulations provide design standards for facilities located in areas that may have potentially damaging ground movements due to movement on active or potentially active faults, or landslides.

3.3.1.3 Paleontology

The Paleontological Resources Preservation Act of 2009 (Public Law [P.L.]111-011) authorizes the BLM and the Forest Service to manage and provide protection to fossil resources using “scientific principles and expertise.” The act defines paleontological resource as “any fossilized remains, traces, or imprints of organisms, preserved in or on the earth's crust, that are of paleontological interest and that provide information about the history of life on earth."

Guidance in the protection, assessment, and mitigation of impacts of paleontological resources is contained in BLM Instruction Memorandum 2009-011 (BLM 2013). The Forest Service has issued final rules for the management and protection of paleontological resources (80 FR 21587). Forest Service also regulates fossil resources under Title 36 CFR 228.62(e) and 261.9(I, j) governing petrified wood and special use authorization for removing any paleontological resource for commercial purposes.

3.3.2 Analysis Area

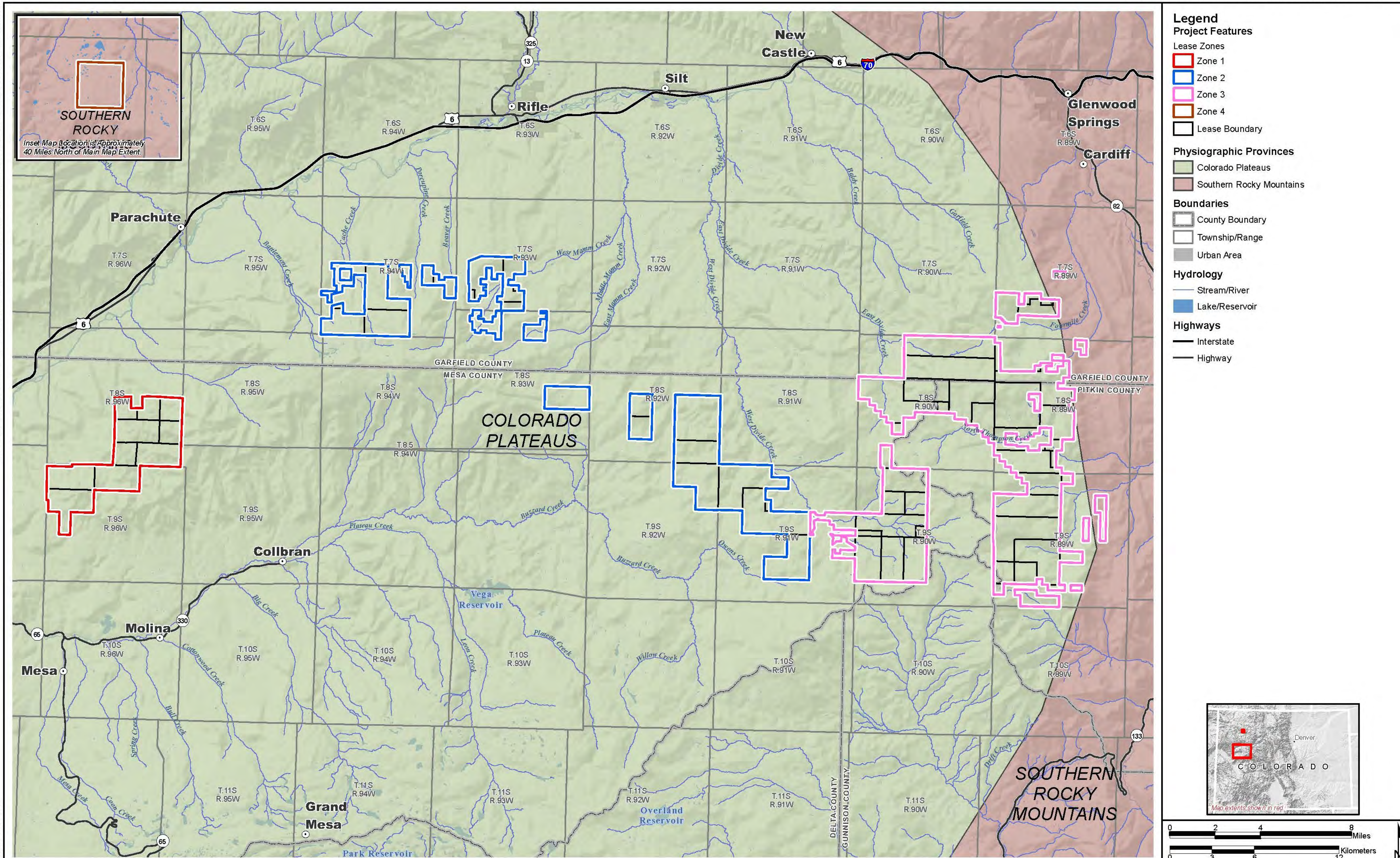
The analysis area for geological, mineral, and paleontological resources consists of the individual lease tracts within the four zones outlined in Chapter 1.0.

3.3.3 Regional Affected Environment

3.3.3.1 Physiography

The analysis area, comprised of the boundaries of the 65 existing leases, is located in two physiographic provinces, shown on **Figure 3.3-1**. Zones 1, 2, and 3 are in the Colorado Plateaus physiographic province, which consists of 140,000 square miles and occupies part of the Four Corners area of Arizona, Colorado, New Mexico, and Utah (Howard and Williams 1972). The Colorado Plateaus province is characterized by buttes and mesas and deeply incised drainages. The province is typified by flat-lying or gently folded sedimentary rocks that range in age from Early Paleozoic to late Cenozoic, but in several areas the boundary of the province is defined by steeply dipping rocks that form hogback ridges. Most of the analysis area is located in a physiographic section called the Uinta Basin, which occupies the northernmost portion of the Colorado Plateaus province. The Uinta Basin consists of two subbasins, the Uinta Basin and the Piceance Basin that are separated by the Douglas Creek Arch that runs north-south parallel to the Utah-Colorado state line. The Piceance Basin is a 7,100-square-mile area that trends northwest to southeast and is approximately 100 miles long and 60 miles wide (Colorado Geological Survey [CGS] 2008). The topography is rugged, consisting of deeply incised plateaus with elevations ranging from 5,000 to 6,000 feet above mean sea level (amsl) in the major river valleys to nearly 11,000 feet in the southern part of the basin. A prominent physiographic feature is the Colorado River Valley that trends generally east to west across the basin. Other prominent features include the Roan Plateau, whose southern boundary forms an imposing escarpment on the north side of the Colorado River Valley; the Grand Hogback, a prominent ridge that forms much of the eastern boundary of the Piceance Basin; Battlement Mesa, a strongly dissected mesa opposite from the Roan Plateau on the south side of the Colorado River; and the Grand Mesa to the south of the Battlement Mesa.

Zone 4 is in the Southern Rocky Mountains physiographic province. The province is characterized by high rugged mountains, with many peaks above 14,000 feet in elevation. The mountain ranges generally trend north to south and are separated by valleys. The Zone 4 lease area is located in a sub-section of the Southern Rocky Mountains called the White River Plateau, which trends northwest to southeast that is about 50 miles long and 50 miles wide and is considered a northward extension of the Sawatch Range (Bass and Northrup 1963). Elevations up to 11,000 feet are common with a large area that is capped with flat-lying sedimentary rocks. A portion of the uplift is referred to as the Flat Tops. The edges of the uplift are cut by deeply incised drainages and the southern boundary of the area is the Glenwood Canyon cut by the Colorado River. Several mountain peaks exceed 12,000 feet in elevation (Bass and Northrup 1963).



Y:\GIS\Projects\BLM_WhiteRiver_OG_EIS_60332451\FIGs\DOC\1_PDEIS\FIG_3_3_1_Physiography_Elevation.mxd
Date: 9/17/2015

Figure 3.3-1 Physiographic Provinces in the Region

This page intentionally left blank

3.3.3.2 Stratigraphy

The Piceance Basin contains 20,000 to 25,000 feet of Phanerozoic sedimentary rocks and deposits ranging in age from Lower Cambrian to Holocene (Jensen and Mitchell 1972; Johnson and Roberts 2003). In addition to the sedimentary rocks, there are Tertiary-aged igneous intrusive and volcanic rocks. Unconsolidated surficial deposits consist of alluvium, glacial material, eolian, and landslide deposits. **Table 3.3-1** shows the regional stratigraphy. Cretaceous, Tertiary, and unconsolidated Holocene deposits are the primary units that are exposed in Zones 1, 2, and 3, as shown in **Figure 3.3-2**. The White River Uplift has approximately 20,000 feet of sedimentary rocks that also range in age from Lower Cambrian to Holocene (Bass and Northrup 1963).

Table 3.3-1 Stratigraphic Chart of the Southeast Piceance Basin and White River Uplift

Era	System	Series	Formation/Unit	Important Hydrocarbon/ Mineral Production	Potential Fossil Yield Classification (PFYC) Rank[1]	Fossils
Cenozoic	Quaternary	Holocene	Unconsolidated deposits including alluvium, glacial, and wind-blown deposits	Sand and gravel	3 and 4	Mammoth, bison
		Pleistocene				
	Tertiary	Pliocene				
		Miocene	Basalt flows		3 and 4	Mammals
		Oligocene	West Elk volcanics		3 and 4	Mammals
		Eocene	Uinta and Green River Formations	Natural Gas	5	Reptiles, fish, insects, plants
		Paleocene	Wasatch Formation	Natural Gas	5	Mammals, fish, reptiles, insects, plants
Cretaceous	Upper Cretaceous		Mesaverde Group	Natural Gas/ coalbed natural gas (CBNG)/Coal	3 and 4	Not determined
			Mancos Shale	Natural Gas	3 and 4	Fish, reptiles
	Lower Cretaceous		Mowry Shale	Oil	3 and 4	Not determined
			Dakota Group	Natural Gas	3 and 4	Not determined
	Jurassic		Morrison Formation	Oil	5	Dinosaurs
			Entrada Sandstone	Oil	3 and 4	Dinosaurs
	Triassic		Chinle Formation	Oil		
			Moenkopi Formation			
Paleozoic	Permian		State Bridge Formation			
			Phosphoria Formation	Oil		
			Weber Sandstone	Oil		
	Pennsylvanian		Maroon Formation			
			Minturn Formation			
			Eagle Valley Formation			
			Beldon Formation			
			Molas Formation			

Table 3.3-1 Stratigraphic Chart of the Southeast Piceance Basin and White River Uplift

Era	System	Series	Formation/Unit	Important Hydrocarbon/ Mineral Production	Potential Fossil Yield Classification (PFYC) Rank[1]	Fossils
Paleozoic	Mississippian		Leadville Limestone			
	Devonian		Gilman Sandstone			
			Dyer Formation			
			Parting Formation			
	Silurian		Not present			
	Ordovician		Manitu Formation			
	Cambrian		Peerless Formation			
			Sawatch Formation			
Precambrian			Igneous and metamorphic rocks			

[1] PFYC rank and fossils shown for those units likely to be affected by ground-disturbing activities, PFYC rank from BLM 2014b.

Source: Bass and Northrup 1963; BLM 2014b; CGS 2008; U.S. Geological Survey (USGS) Uinta-Piceance Assessment Team 2003.

3.3.3.1 Structural Geology

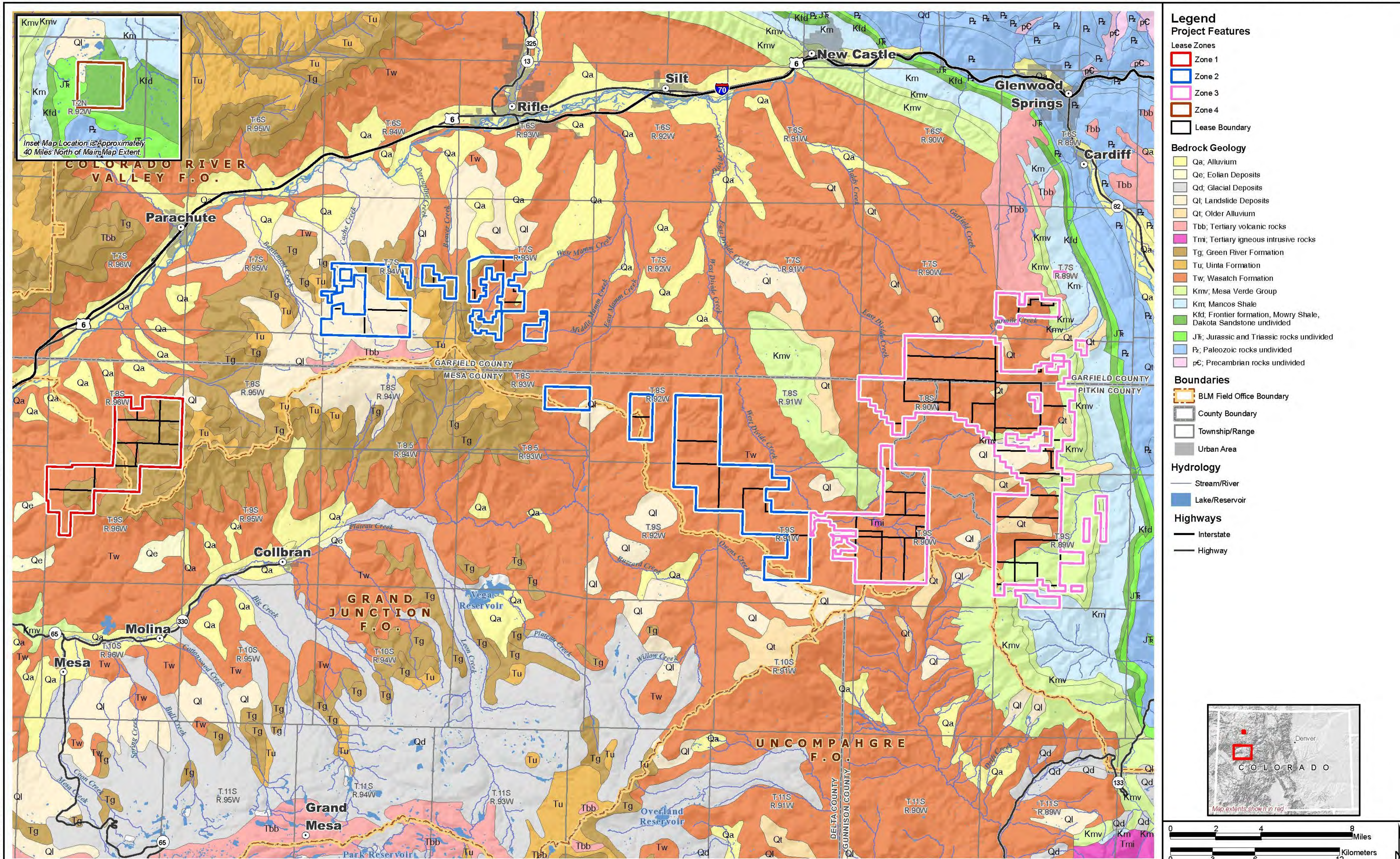
The Piceance Basin was formed at the end of Cretaceous and early Tertiary during the Laramide mountain building period. The basin is asymmetric with very steeply dipping strata on the east side with the deepest part of the basin in the northeast portion of the basin (**Figure 3.3-3**). The steep dips on the east side of the basin have resulted from basin-bounding faults and the uplift of Cretaceous sedimentary rocks is displayed along the Grand Hogback. There are many internal structures within the basin, with a dominant trend from northwest to southeast. Of interest to this study are the Wolf Creek, Divide Creek, Coal Basin, and the DeBeque Anticlines (USGS Uinta-Piceance Assessment Team 2003).

The structure of the White River uplift is a slightly elongated dome (Bass and Northrup 1963). On the crest of the uplift, structural dips are gentle or flat, but on the boundaries of the uplift the rocks dip steeply having been uplifted along bounding faults. Along the southwest flank of the uplift where it bounds the Piceance Basin at the Grand Hogback, sedimentary rocks have dips from 50 to 90°F and in some areas are completely overturned. There are extensive faults trending west to east in the southern part of the uplift. A number of northwest-to southeast-trending folds are present where the Axial Basin, the northeast Piceance Basin, and the Sand Wash Basin bound the northern portion of the White River Uplift. One of these folds is the Yellowjacket Anticline, a north-trending fold that is located in Zone 4 lease area (Reheis 1984).

3.3.3.2 Geological Hazards

Landslides

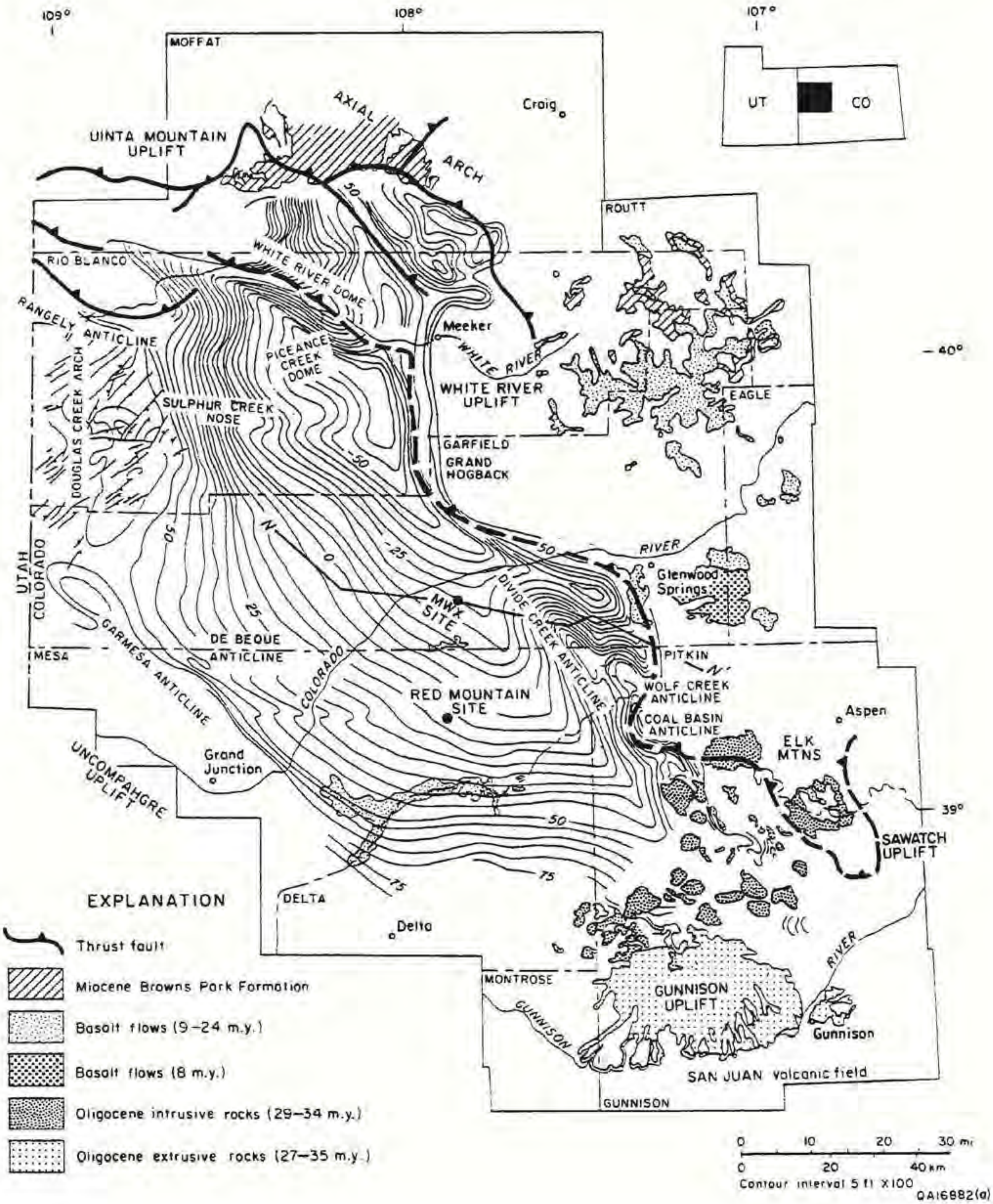
The analysis area (all lease zones) is highly prone to landslides, debris flows, and mass movements of slump-blocks (see **Figure 3.3-4**, Landslides). Much of the underlying instability in the Grand Mesa-Battlement Mesa area has been the result of rapid erosion of Eocene-aged sedimentary rocks and undercutting of overlying volcanic flows (Yeend 1969). Landslides also have been known to occur in upper Cretaceous rocks of the Mesaverde and Mancos Formations (Cole et al. 2014). Numerous landslides have been mapped in the area and movement on many slides can reoccur depending on the



E:\GIS\Projects\BLM_WhiteRiver_OG_EIS_60332451\FIGS\DOC\1_PDEIS\FIG_3_3_2_Regional_Bedrock_Geology.mxd
Date: 9/17/2015

Figure 3.3-2 Regional Bedrock Geology

This page intentionally left blank



Source: Tyler 1996

Figure 3.3-3 Regional Geologic Structure

This page intentionally left blank

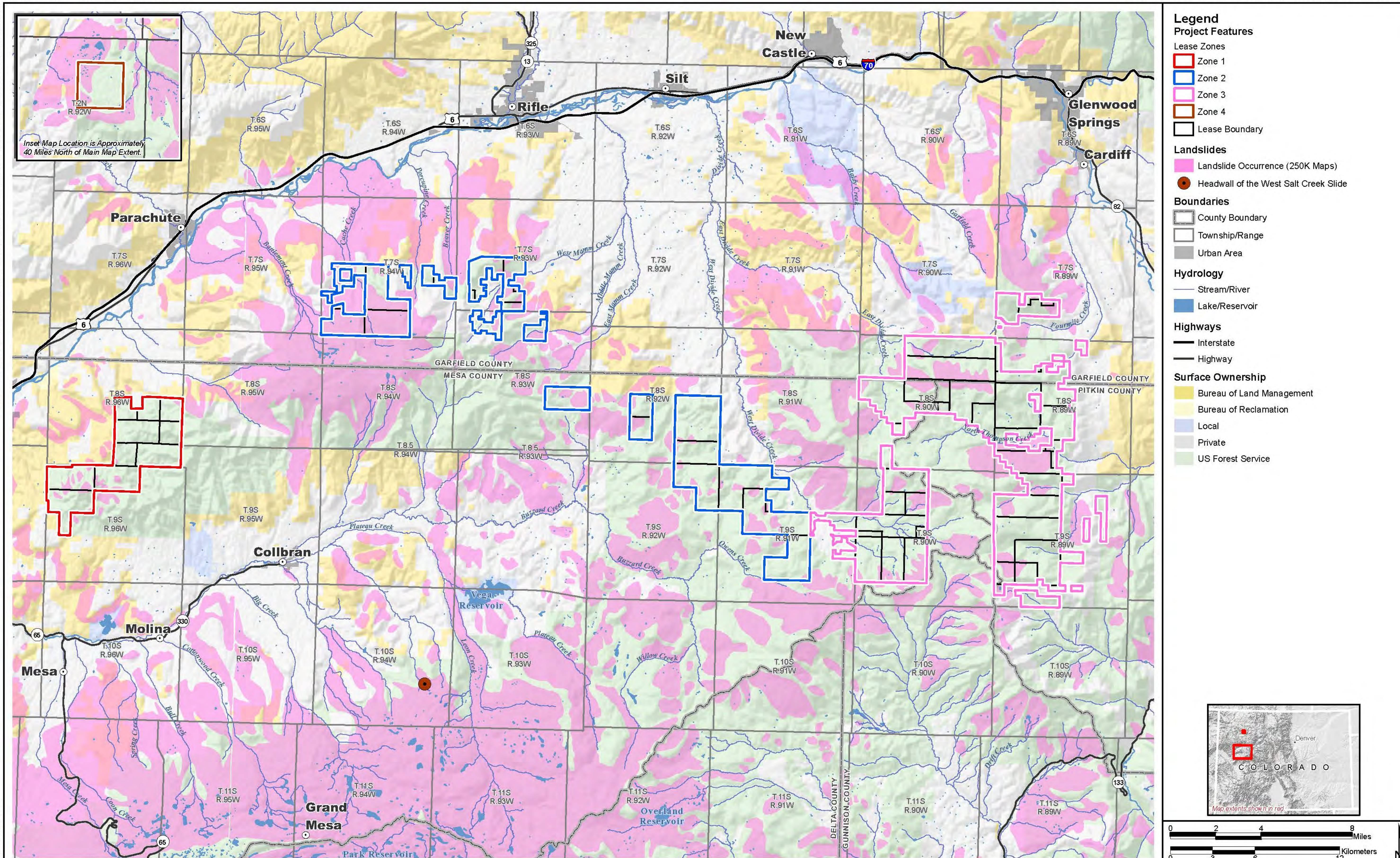


Figure 3.3-4 Landslide Occurrence

This page intentionally left blank

amount of precipitation (Soule 1988). A recent massive landslide occurred on May 27, 2014, that involved three fatalities. The landslide, referred to as the West Salt Creek slide, is located in Township 10 South (T10S), Range 94 West (R94W), about 6 miles southeast of Collbran, Colorado. The slide is approximately 2.8 miles long, 0.5 mile wide, 150 feet thick, and involved 39 million cubic yards of material (Cole et al. 2014). The slide occurred in an area of pre-existing landslide deposits and unconsolidated materials. It is thought that high amounts of precipitation and the steep topographic gradient in the West Salt Creek drainage contributed to a reactivation of an old slump block.

Seismicity and Faults

A search of the USGS earthquake catalog was conducted to determine level of earthquake activity in the analysis area (USGS 2015). Using search parameters centered on latitude 39.5 degrees north and longitude 108 degrees west and a cutoff of less than magnitude 3.0, it was determined that there were about 60 epicenters (mostly magnitude 3.0 to 4.0), but more than half of the epicenters were rock bursts that appear to be associated with coal mining in the Paonia, Colorado area, approximately 30 miles south of the analysis area. Rock bursts occur during longwall mining when the coal is mined out and roof support is removed and the mined out area collapses.

The estimates of seismic hazards in any given area in the country are based on the mapping of Quaternary (the last 1.6 million years) faults (USGS and CGS 2006). There are Quaternary faults located in T7S and T8S, R88W and R89W along the Grand Hogback (see **Figure 3.3-5**).

Induced Seismicity

Coal mine rock bursts described above are examples of the phenomena of induced seismicity, in which human activities cause earthquakes to occur. In addition to mining, activities that cause seismicity include subsurface injection and withdrawal of fluids, water reservoirs, and nuclear explosions. Of interest here is induced seismicity caused by the injection of fluids, which may alter the stresses on the rocks, creating a situation where faults can be activated. In the northern Piceance Basin at Rangely oil field, injection during waterflood operations in the 1960s was thought to be the cause of slight tremors (Cypser 1996). In an effort to ascertain whether the tremors were actually caused by injection activities, USGS researchers in 1970 conducted a series of tests and established a strong relationship between increases and decreases in injection pressures and the frequency of earthquakes.

Caves and Karst

Karst topography occurs in areas that are underlain by carbonate rocks or evaporite minerals (salt, gypsum, or anhydrite) that have undergone dissolution by water. Karst topography is typified by depressions, sinkholes, disappearing streams, and cave openings (Tobin and Weary 2004). Karst topography is common in the White River Plateau and is due primarily to the dissolution of the Leadville Limestone and gypsum and anhydrite beds in the Eagle Valley Evaporite. Over 60 caves have been identified in the in the Leadville Limestone of the White River Plateau (Teller and Welder 1985). The Leadville Limestone also has many features of paleokarst, dissolution features from a late Mississippian period of karst development (De Voto 1988). No caves have been identified in the vicinity of the lease zones, but Spring Cave is located in the White River National Forest near the South Fork Campground, approximately 15 miles southeast of Zone 4.

Evaporite karst is common in the form of sinkholes and depressions which occur where the Eagle Valley Evaporite is relatively shallow and dissolution of the salt and gypsum causes collapse of the overlying unconsolidated materials (Mock 2002). There is some potential for karst in the Carbondale, Colorado, area. **Figure 3.3-6** displays the karst areas. Although potential karst areas are shown to extend into leases in Zone 3, the formations that are susceptible to karst (the Eagle Valley Evaporite and the Leadville Limestone are too deep to be of concern for the formation of karst hazards.

3.3.3.3 Minerals

Oil, Gas, and Coalbed Natural Gas

In the Uinta-Piceance petroleum province, the mean undiscovered oil and gas resource including Coalbed Natural Gas (CBNG) is 21 trillion cubic feet of gas and 59 million barrels of oil and 43 million barrels of natural gas liquids (USGS Uinta-Piceance Assessment Team 2003). There are numerous gas fields in the analysis area as shown on **Figure 3.3-7**. Hydrocarbon production comes from a variety of formations as shown on **Figure 3.3-2**. The major commodity produced is natural gas, which includes CBNG. Most CBNG in the Piceance Basin has been produced from the Cameo-Fairfield coal group of the Mesaverde Formation (CGS 2008). It is difficult to summarize CBNG production because coal gas production is often intermingled with natural gas from sandstone reservoirs due to the practice of large-interval staged hydraulic fracturing in vertical or directional wells.

Much of the non-coal gas is found in "tight" (low permeability) sandstones, mainly the Mesaverde and the Wasatch formations. It is expected that most future gas production would come from the Mesaverde Group (BLM 2008a), but there is potential for shale gas production from the Mancos Shale. Although gas has been produced out of conventional sandstone reservoirs in the Mancos "B" zone, the Mancos may have potential as an unconventional shale play. In 2013, WPX reported initial production from a Mancos Shale well to be 16 million cubic feet of gas per day and produced 1.0 billion cubic feet in 100 days (Niobrara News 2013). However, other horizontal attempts at the Mancos Shale have produced mixed results and with low natural gas prices, the foreseeable potential of shale gas in the Mancos is not certain.

The northern edge of the White River Plateau where Zone 4 is located has some oil fields that are associated with the anticlines along the northern boundary of the White River uplift. These oil fields include McHatton, Nine-Mile, Thornburgh, and Scott Hill.

Other Minerals

In addition to oil and gas, there are other mineral commodities in the analysis area, including coal, oil shale, uranium, and aggregate. **Figure 3.3-8** displays the permitted mines in the analysis area.

Coal

The analysis area is in the Uinta Coal Region, which the USGS divides into several coal resource assessment units. Zones 1, 2, and 3 lie within the South Piceance Basin Assessment Unit, is estimated to have a mineable resource to 3,000 feet deep of 82 billion tons from coals in the upper Cretaceous Mesaverde formation (Brownfield et al. 2000). Only Zone 3 contains potential coal mining areas along the Grand Hogback, but there are no active mines. In 2007, almost 19 million tons of coal was produced from mines in the southern Piceance Basin assessment area (Burnell et al. 2007).

Uranium

Uranium deposits in the Piceance Basin are likely to occur in the Morrison, Entrada, and Chinle formations and the Navajo Sandstone (Nelson-Moore et al. 1978). Uranium ore was mined from several occurrences in Garfield County, all located north of the Colorado River. The ore was processed at a mill in Rifle, Colorado. There are numerous uranium occurrences in T2N, R92W, where the Zone 4 is located. No active mining is occurring at the present time.

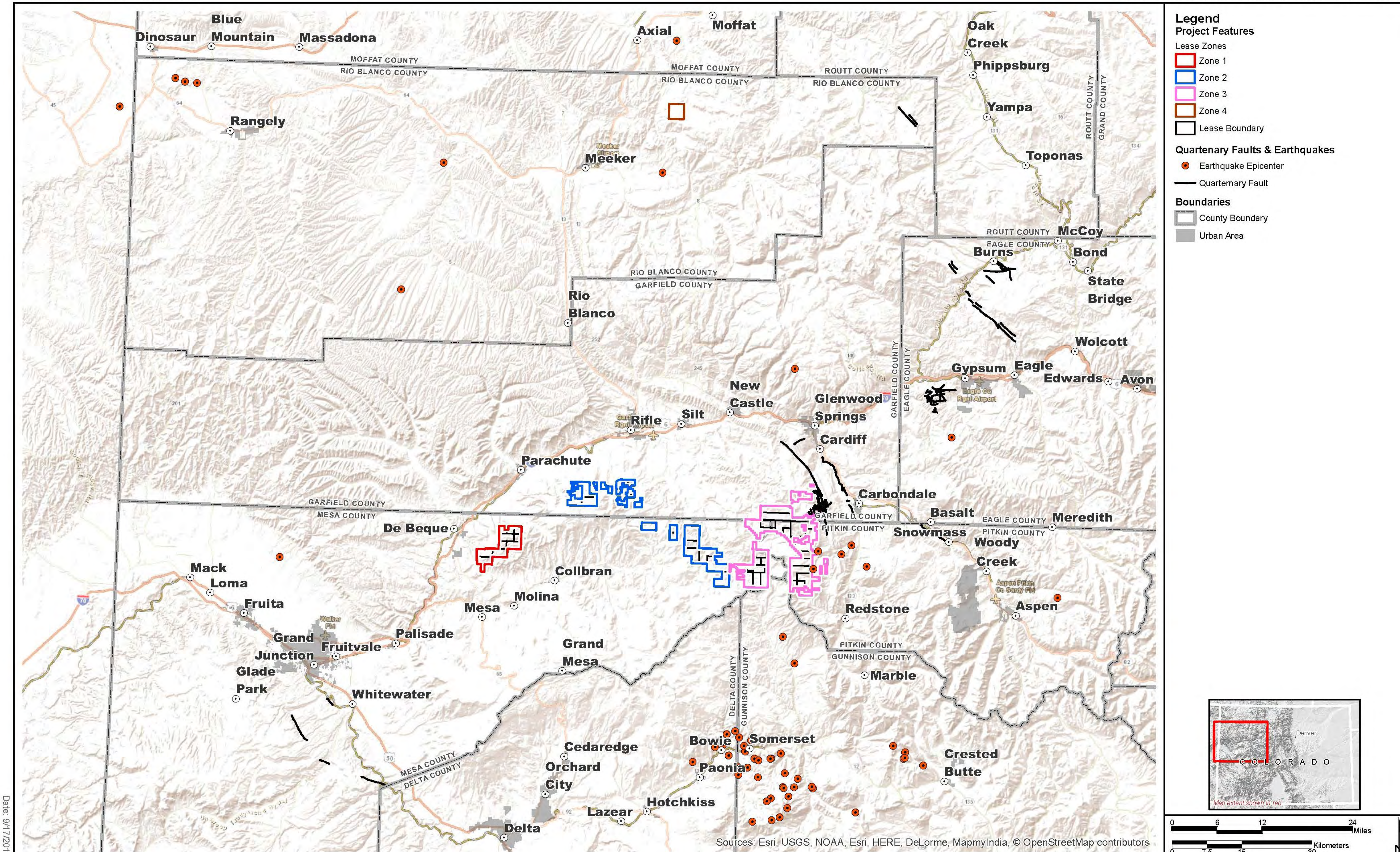


Figure 3.3-5 Quaternary Faults and Earthquake Epicenters

Y:\GIS\Projects\BLM_WhiteRiver_OG_EIS_60332451\FIGs\DOC1_PDEIS\FIG_3_3_6_Karst.mxd

Date: 9/17/2015

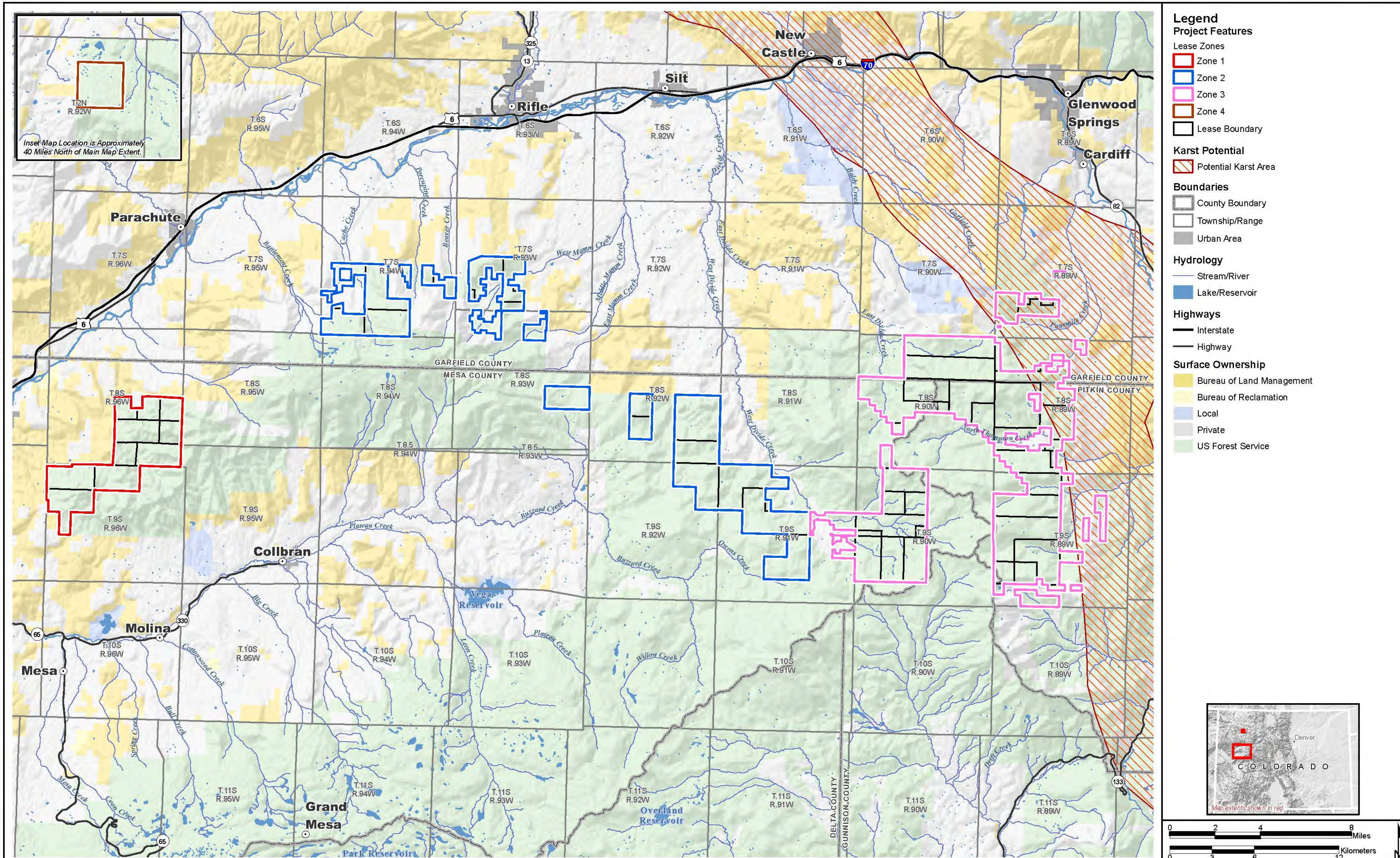
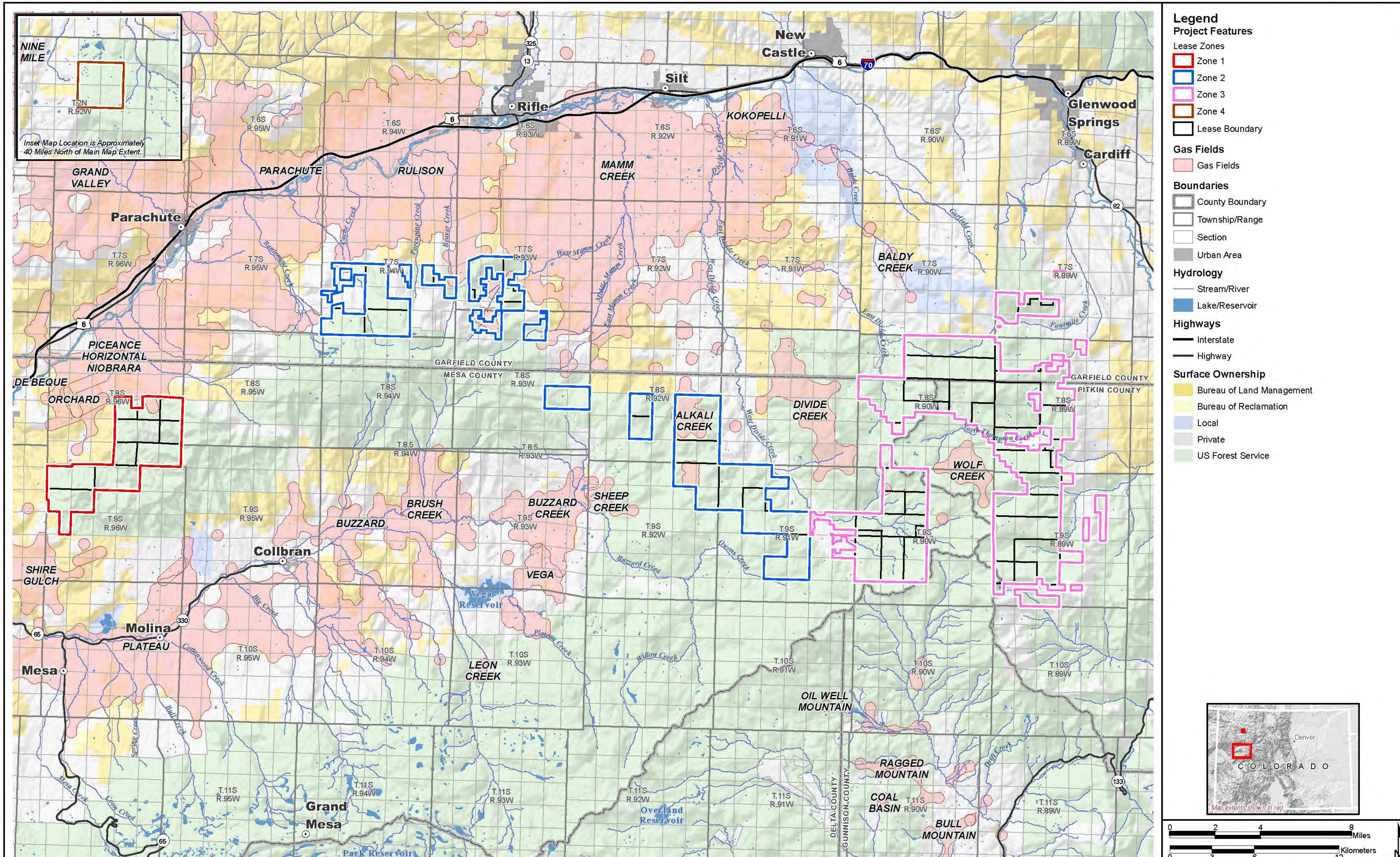


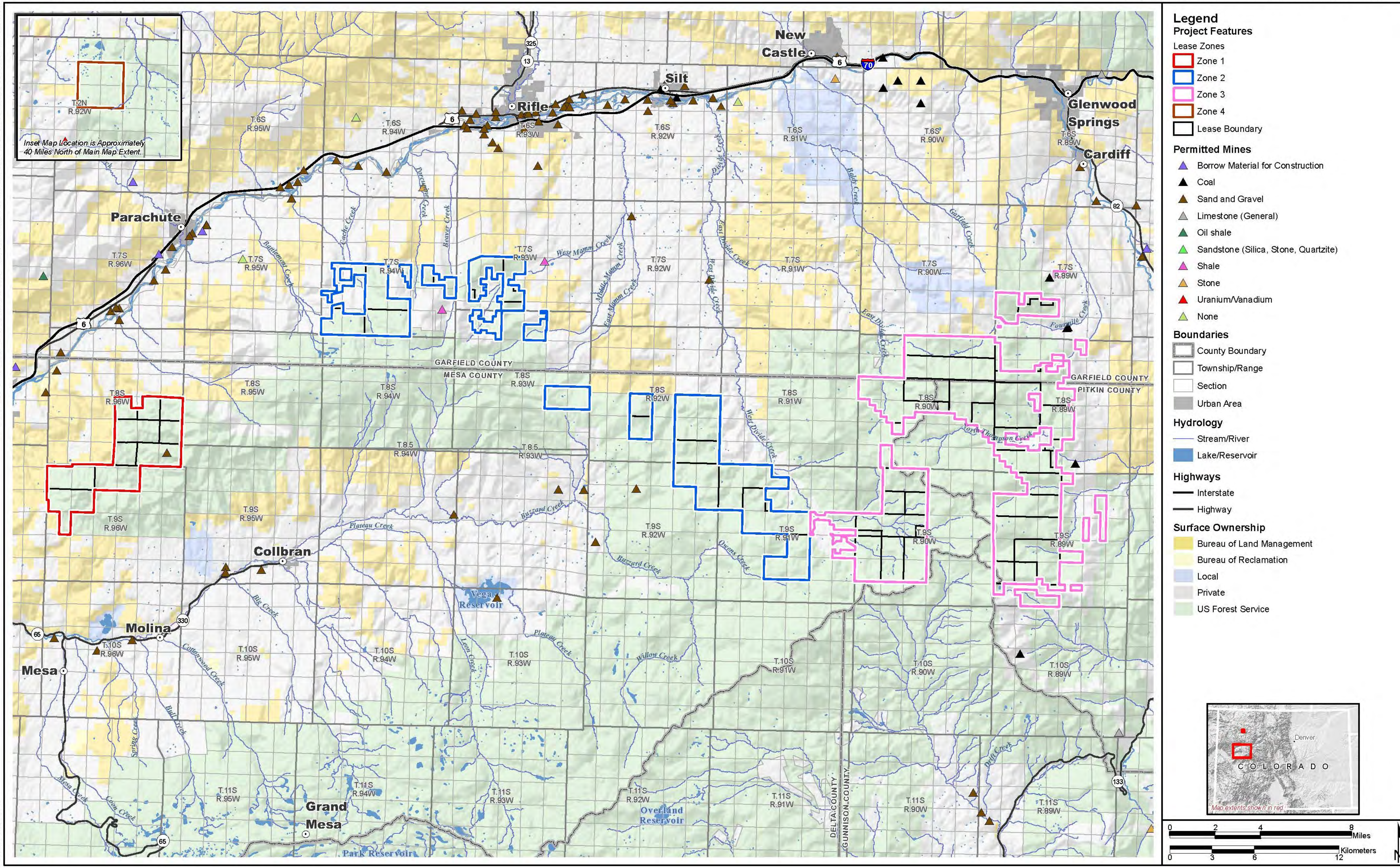
Figure 3.3-6 Karst Areas

Y:\GIS\Projects\BLM_WhiteRiver_OG_EIS_60332451\FIGS\DOC1_PDEIS\FIG_3_3_7_Oil_Gas_Fields.mxd



Date: 9/17/2015

Figure 3.3-7 Oil and Gas Fields in the Analysis Area



Y:\GIS\Projects\BLM_WhiteRiver_OG_EIS_60332451\FIGS\DOC1_PDEIS\FIG_3_3_8_Permitted_Mines.mxd

Date: 9/17/2015

Figure 3.3-8 Permitted Mines in the Analysis Area

Oil Shale

Oil shale is a marlstone that contains large amounts of kerogen, an organic material that is a precursor to hydrocarbons. Oil shale is an immature hydrocarbon source rock that, when subjected to heat, the kerogen is converted to oil (USGS 2015). Oil shale occurs in abundance in the Green River Formation of the Piceance Basin, but the high grade deposits (oil yield greater than 25 gallons per ton) occur north of the Colorado River.

Aggregate

Sand and gravel commonly occur in alluvial deposits, but crushed stone also can provide gravel-sized material. In the analysis area, there are numerous sand and gravel pits located adjacent to the Colorado River and along Plateau Creek on Grand Mesa (**Figure 3.3-8**) (Guilinger and Keller 2004).

Geothermal Energy

The lease zones are located in an area of moderate heat flow and hot springs located in the analysis area are indicative of geothermal potential (Berkman and Carroll 2007). However, there is no power generation by geothermal energy in the area. Hot springs at Glenwood Springs and at Penny Hot Springs in northwest Pitkin County are evidence of geothermal potential in the area.

3.3.3.4 Paleontological Resources

The BLM adopted the PFYC system to identify and classify fossil resources on federal lands (BLM 2013). Under this system, paleontological resources are closely tied to the geologic units (i.e., formations, members, or beds) that contain them. The probability for finding paleontological resources can be broadly predicted from the geologic units present at or near the surface. Therefore, geologic mapping can be used for assessing the potential for the occurrence of paleontological resources.

The PFYC system is a way of classifying geologic units based on the relative abundance of scientifically important fossils (plants, vertebrates, and invertebrates) and their sensitivity to adverse impacts. A higher class number indicates higher potential for the occurrence of fossils of scientific importance. The PFYC system is not intended to be applied to specific paleontological localities or small areas within units. Although important localities may occasionally occur in a geologic unit, a few widely scattered important fossils or localities do not necessarily indicate a higher class; instead, the relative abundance of significant localities is intended to be the major determinant for the class assignment. The classification should be used to assist in determining the need for further mitigation, assessment, or other actions. The BLM intends for the PFYC system to be used as a guideline as opposed to rigorous definitions. Descriptions of the potential fossil yield classes are summarized below:

- Class 1—Igneous and metamorphic geologic units (excluding tuffs) that are not likely to contain recognizable fossil remains.
- Class 2—Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically important nonvertebrate fossils.
- Class 3—Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or unknown potential, but could contain fossils based on geologic features or apparent preservation condition.
- Class 4—Geologic units are Class 5 units that have lower risks of human-caused adverse impacts or lower risk of natural degradation. Proposed ground-disturbing activities would require assessment to determine whether significant paleontological resources occur in an area of proposed disturbance.

- Class 5—Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or scientifically important nonvertebrate fossils and that are at high risk of natural degradation or human-caused adverse impacts.

The analysis area contains an abundance of high-value paleontological resources. The fossil occurrence in each formation is summarized in **Table 3.3-1**. PFYC ranks are provided for those formations where there is a strong possibility that those formations could be affected by ground-disturbing activities. The PFYC ranks were taken from CRVFO Final Resource Management Plan (RMP) EIS (BLM 2014b). **Figure 3.3-9** shows the distribution of PFYC ranks. **Table 3.3-2** summarizes the extent of the high-value paleontological resources (PFYC 3 and 5) in each lease zone in the analysis area.

Table 3.3-2 Extent of High-value Fossil Formations by Zone

Zone No.	Zone Acres	% of PFYC 3 by Zone	% of PFYC 5 by Zone	% of PFYC 3 and 5 by Zone
1	10,114	56	44	100
2	24,938	28	71	99
3	42,767	9	90	99
4	2,562	93	7	100
Total	**80,381**	**24**	**76**	**100**

3.3.4 Analysis Area Affected Environment

3.3.4.1 Zone 1

<u>Stratigraphy and Structure</u>

The bedrock in Zone 1 consists of the Tertiary Wasatch, Green River, and Uinta formations (Ellis and Freeman 1989). These formations are composed of sandstone, siltstone, and shale. Surficial deposits are alluvium, older gravel deposits, and landslide material. The sedimentary strata dip gently to the northeast. The De Beque Anticline is a west- to east-trending structure, but is mapped only west of the Colorado River by Ellis and Freeman (1989), so it is not certain if this structure underlies any of the leases in Zone 1.

<u>Geologic Hazards</u>

Landslides have been identified in leases in the southern portion of Zone 1 (**Figure 3.3-5**). The slides have involved material from the Wasatch and Green River Formations. No Quaternary faults are present in Zone 1.

<u>Mineral Resources</u>

The primary mineral resources in Zone 1 are natural gas and CBNG. The leases in Zone 1 are located between the Parachute and Grand Valley fields to the north and Shire Gulch and Plateau fields to the south. The primary production zones are sandstones of the Mesaverde Group, but other producing horizons include Wasatch, Mancos, Frontier, Dakota, and Morrison Formations (COGCC 2015d). Each of these fields has horizontal Mancos Shale completions located in T8S and T9S, R96W. Coal is present in the Mesaverde Group, but it is too deep to mine. No uranium occurrences have been identified in Zone 1 (Nelson-Moore et al. 1978). Oil shale beds may be present in the Green River Formation, but are likely to be low grade, compared to the higher rank oil shale north of the Colorado River on the Roan Plateau. Zone 1 is in an area of moderate geothermal heat flow, but no hot springs or wells are located within the zone.

Y:\GIS\Projects\BLM_WhiteRiver_OG_EIS_60332451\FIGs\DOC1_PDEIS\FIG_3_3_9_Pot_Fossil_Yield.mxd

Date: 9/17/2015

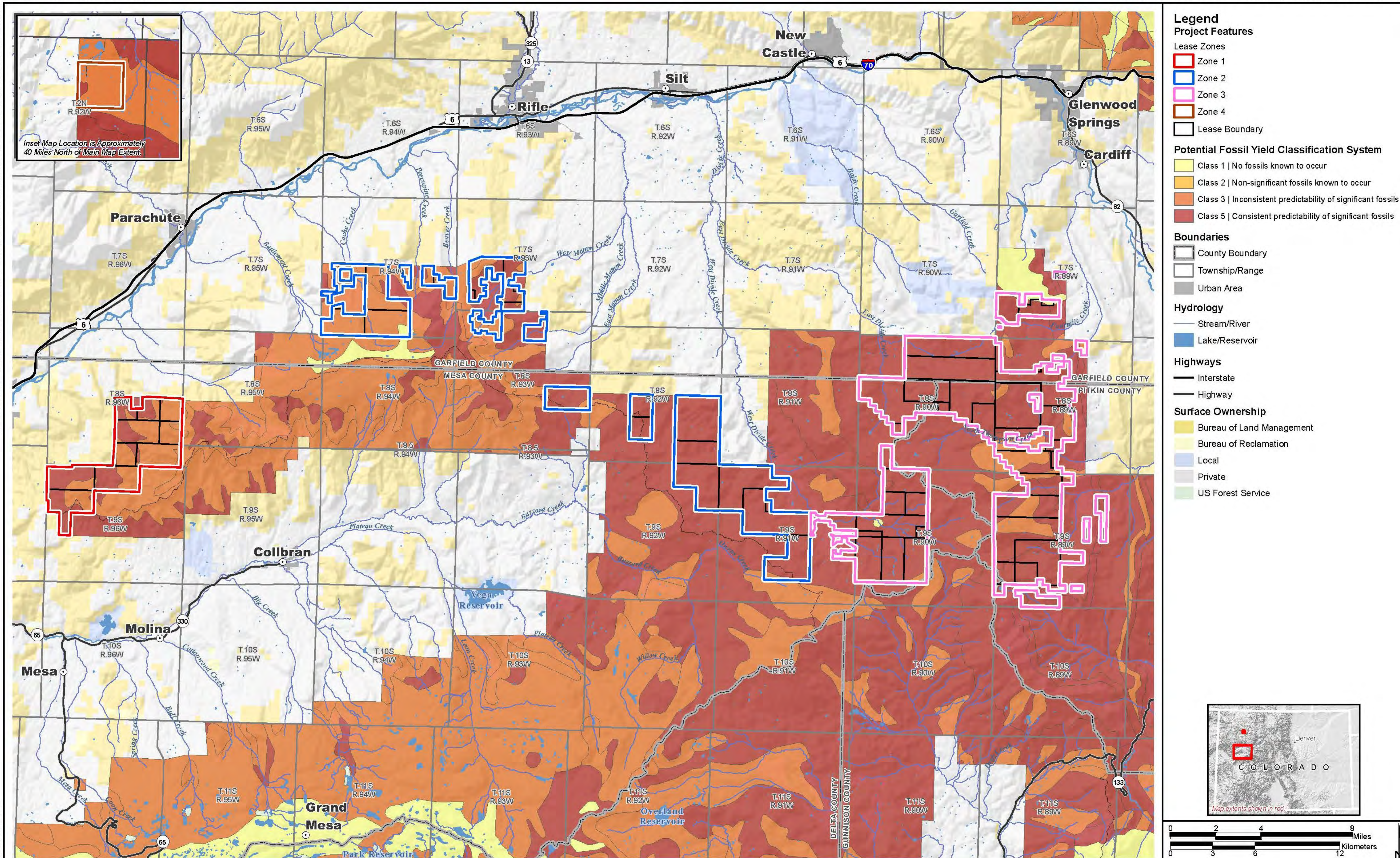


Figure 3.3-9 Potential Fossil Yield Classes in the Analysis Area

This page intentionally left blank

Paleontological Resources

Because the bedrock units and deposits are considered to have PFYC ranks ranging from 3 to 5, there is a moderate to high probability that scientifically important fossils are present in Zone 1.

3.3.4.2 Zone 2

Stratigraphy and Structure

The bedrock deposits in Zone 2 consist of the Cretaceous upper Mesaverde Group, Tertiary Green River Formation (including the Parachute Creek Member), the Uinta Formation, and Miocene and Pliocene basalts (Tweto 1979; Tweto et al. 1978). The unconsolidated formations are alluvium, terrace deposits, and landslides. The regional structural dip is regionally to the northeast, but the Divide Creek Anticline interrupts the regional dip in the northeast portion of Zone 2. The Divide Creek Anticline is elongate northwest to southeast and the Mesaverde formation is exposed for about 10 miles along the core of the anticline.

Geologic Hazards

Landslides have been mapped in Zone 2 leases (**Figure 3.3-5**). The landslides have occurred due to erosion of Green River Formation rocks that underlie volcanic flows that cap Battlement Mesa. There are no Quaternary faults that have been identified in Zone 2.

Mineral Resources

Natural gas and CBNG are the main mineral resources in Zone 2 and the subject leases are located adjacent to and within the following fields: Rulison, Mamm Creek, Alkali Creek, and Divide Creek (COGCC 2015d). The producing zones include the Wasatch, Mesaverde Group, and Mancos Shale. As in Zone 1, no uranium occurrences have been identified in Zone 2 (Nelson-Moore et al. 1978). Oil shale beds may be present in the Green River Formation, but are likely to be low grade, compared to the higher rank oil shale north of the Colorado River. Zone 2 is in an area of moderate geothermal heat flow, but no hot springs or wells are located its boundaries.

Paleontological Resources

Because the bedrock units and deposits are considered to have PFYC ranks ranging from 3 to 5, there is a moderate to high probability that scientifically important fossils are present.

3.3.4.3 Zone 3

Stratigraphy and Structure

The bedrock units in Zone 3 include the Cretaceous Mancos Shale, Mesaverde Group, and Tertiary Wasatch Formation (Ellis and Galbaldo 1984). Surficial deposits consist of alluvium, gravel deposits, and landslides. The Wolf Creek Anticline is the major structural feature in Zone 3 and is more dome-shaped than the Divide Creek Anticline with Cretaceous rocks exposed along the flanks and the core of the structure.

Geologic Hazards

Landslides are present in in many of the Zone 3 leases. Quaternary faults have been identified within or adjacent to leases in Zone 3. The Grand Hogback Faults/Fourmile Creek-Unnamed fault, located in Section 34, T7S, R89W, is believed to be active. There is evidence that the fault has cut Holocene deposits (less than 15,000 years old) and movement has taken place in the last 15,000 years. This active fault zone has the potential to generate earthquakes that could create ground motions ranging from 20 to 40 percent of the acceleration of gravity (USGS 2014). The fault is just to the north of lease COC 066693, which is located in Section 3, T8S, R89W.

On the east side of Zone 3 there are leases that are within an area that has been identified having potential for the development of karst (**Figure 3.3-7**). The karst potential derives from the presence of Eagle Valley Evaporites in the subsurface.

Mineral Resources

The important mineral resources in Zone 3 are natural gas and CBNG. Natural gas in Mesaverde Group sandstones was discovered on the Wolf Creek Anticline in the early 1960s, but was converted to gas storage in 1972 (BLM 2008). Coal is present in the Mesaverde Group that outcrops on the flanks of the Wolf Creek structure and historic coal mining occurred on the Grand Hogback in T7S and T8S, R88W (Wideman et al. 2002). No uranium occurrences have been identified in Zone 3 (Nelson-Moore et al. 1978). The Green River Formation has largely been eroded from this area, so there is no oil shale potential. Penny Hot Springs is located in Section 4, T10S, R88W, in northwest Pitkin County (Barrett and Pearl 2006). The springs are located along the Crystal River in the vicinity of Redstone, Colorado, and temperature of the water varies from 104°F to 115°F (40 to 46 degrees Celsius). These springs are not developed for use.

Paleontological Resources

Because the bedrock units and deposits are considered to have PFYC ranks ranging from 3 to 5, there is a moderate to high probability that scientifically important fossils are present in Zone 3.

3.3.4.4 Zone 4

Stratigraphy and Structure

Bedrock in Zone 4 consists of the Cretaceous Mesaverde Group, Mancos Shale, and Dakota Formation, Jurassic Morrison Formation, Jurassic-Triassic Entrada-Glen Canyon Sandstones, and the Triassic Chinle Formation (Reheis 1984). Alluvium is present in the drainages, but there are extensive landslide deposits, probably the result of instability in the lower Mancos Shale and the Dakota Formation (Reheis 1984). Zone 4 sits astride a northwest trending structure called the Yellowjacket Anticline.

Geologic Hazards

Landslides have been mapped within the Zone 4 lease and resulted from mass-wasting of material from the Mancos, Dakota, and Morrison Formations (Reheis 1984). No Quaternary faults are located within or near the Zone 4 lease (USGS and CGS 2006). No karst potential has been identified in the vicinity of Zone 4 (Tobin and Weary 2004).

Mineral Resources

The Yellowjacket Anticline has been the site of various failed attempts to discover oil and gas production (Rehies 1984). The closest oil fields are Ninemile Field, a few miles west of Zone 4, and the Thornburgh Field, approximately 5 miles north of Zone 4 (COGCC 2015d). Mineable coals in Mesaverde Group formations are present in the vicinity (Reheis 1984). The Morrison Formation hosted several uranium occurrences in T2N, R92W where Zone 4 is located. Most of the deposits were mined by stripping or underground methods, but did not yield a large amount of ore, usually less than 500 tons (Nelson-More et al. 1978), although one deposit was mined for 12,000 tons. Zone 4 is in an area of moderate geothermal heat flow, but contains no hot springs or wells.

Paleontological Resources

Because the bedrock units and deposits are considered to have PFYC ranks ranging from 3 to 5, there is a moderate to high probability that scientifically important fossils are present in Zone 4.

3.4 Soils

3.4.1 Regulatory Background

Soil resources are managed through a broad set of regulations, guidelines, and formal planning processes. These controls and directions are administered through federal, state, or local units of government. At the federal level, primary land management agencies include the Forest Service and the BLM. The Forest Service addresses soil resource management primarily by cooperating in the Colorado River Salinity Control Program and by implementing policy set forth in the LRMP. The LRMPs set management, protection and use goals and guidelines. The FSM, Soil Management (Chapter 2550) and the Forest Service Handbook, Watershed Conservation Practices Handbook (Chapter 2509.25) specific to each region also provide policy and guidance on managing soil resources. On lands administered by the BLM, the agency addresses soil resources primarily through BLM Handbook H-4810-1, “Rangeland Health Standards,” and by participating as a cooperating agency in the Colorado River Salinity Control Program.

3.4.2 Analysis Area

The analysis area for soil resources consists of the 65 leases within the 4 zones. A variety of data sources were used to identify the baseline soil characteristics in the analysis area. Information on Major Land Resource Areas (MLRAs) was obtained from Natural Resources Conservation Service (NRCS) literature or databases, including the Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin, U.S. Department of Agriculture (USDA) Handbook 296 (USDA 2006). The GMUGNF soil survey data has been correlated and is available through the NRCS 2015 Gridded Soil Survey Geographic (gSSURGO) Database (NRCS 2015). Soil resources on the WRNF were characterized by the review of two unpublished draft soil surveys that are pending correlation, the Flat Tops Area Soil Survey and the Holy Cross Area Soil Survey, maintained by the WRNF.

3.4.3 Regional Affected Environment

The lease boundaries lie within the following MLRAs (USDA 2006), shown on **Figure 3.4-1**:

- MLRA 34B – Warm Central Desertic Basins and Plateaus; and
- MLRA 48A – Southern Rocky Mountains

The Warm Central Desertic Basins and Plateaus Major Land Resource Area consists of broad intermountain basins bounded by plateaus and steep escarpments. The elevation ranges from 4,100 feet amsl at the base of the Wasatch Range to 7,500 feet amsl on the Roan Plateau (USDA 2006).

The soils in MLRA 34B primarily formed in slope alluvium and residuum derived from shale or sandstone. The soils that formed in material weathered from Mancos Shale tend to have active or semiactive clay activity classes. Soils that formed in alluvium occur near the major waterways, and soils that formed in colluvium occur generally on slopes of more than 35 percent. Many of the soils are shallow or moderately deep to shale or sandstone bedrock. The majority of the soils are well drained and calcareous. The soils at the lower elevations generally have significant amounts of calcium carbonate, salts, and gypsum. The dominant soil orders in this MLRA are Aridisols and Entisols. Aridisols form in an arid or semi-arid climate and have a low concentration of organic matter. Entisols are considered recent soils that lack soil development because erosion or deposition rates occur faster than the rate of soil development (USDA 2006).

The Southern Rocky Mountains MLRA consists primarily of two belts of strongly sloping to precipitous mountain ranges trending north to south. Several basins, or parks, are between the belts. The elevation ranges from 6,500 to 14,400 feet amsl. Many of the highest mountain ranges were reshaped by glaciation. Alluvial fans at the base of the mountains are recharge zones for aquifers (USDA 2006).

The soils in MLRA 48A primarily formed in slope alluvium and colluvium on mountain slopes or residuum on mountain peaks derived from igneous, metamorphic, and sedimentary parent materials. Younger igneous parent materials, primarily basalt and andesitic lava flows, tuffs, breccias, and conglomerates, are located throughout this area. The dominant soil orders in this MLRA are Mollisols, Alfisols, Inceptisols, and Entisols. Mollisols are fertile soils with high organic matter and a nutrient-enriched, thick surface. Alfisols have at least 35 percent base saturation, meaning calcium, magnesium, and potassium are relatively abundant. In contrast, Inceptisols form in humid and subhumid climates and have altered horizons that have lost bases or iron and aluminum but retain some weatherable minerals (USDA 2006).

3.4.4 Analysis Area Affected Environment

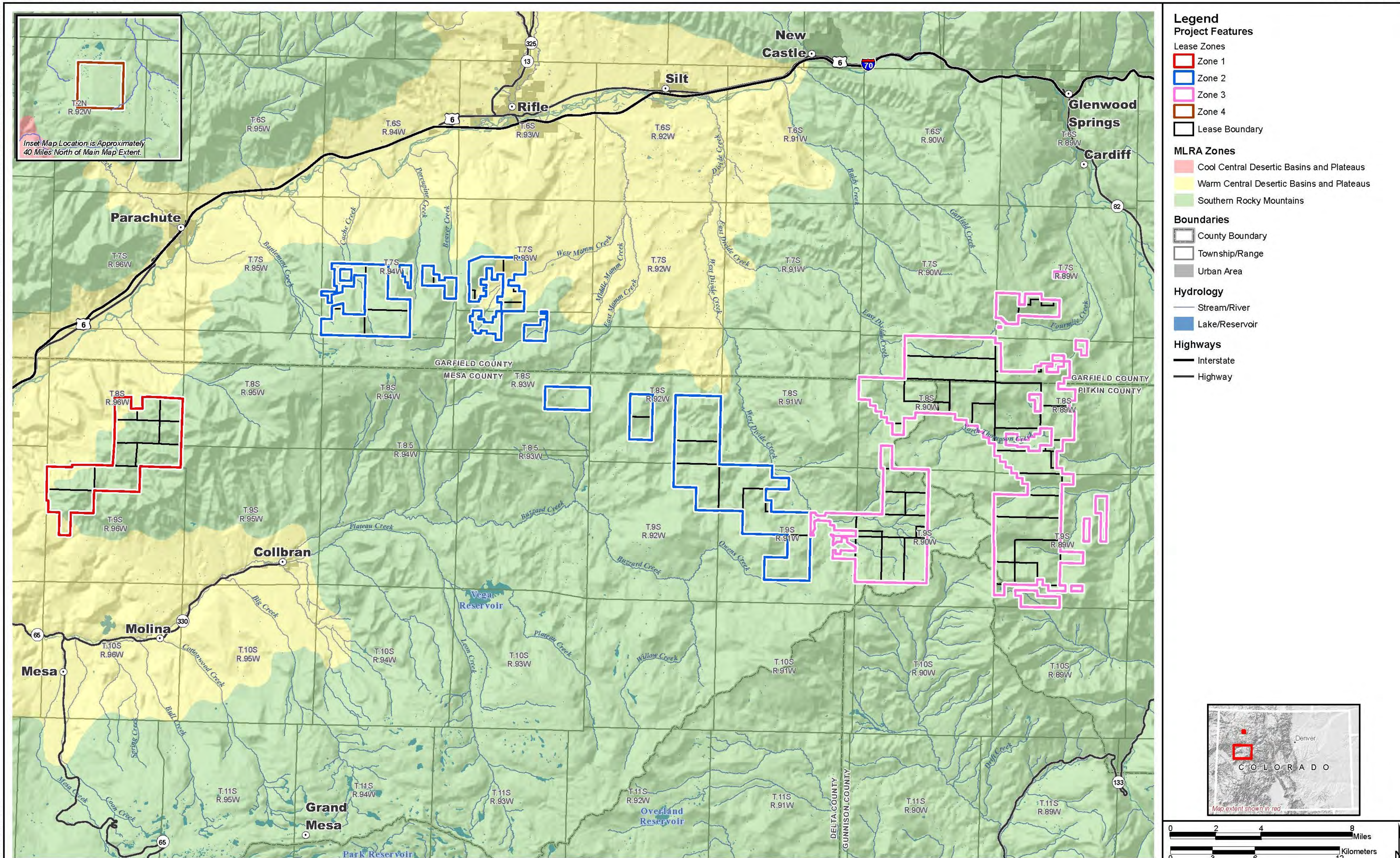
This section provides the existing conditions and context for the evaluation of potential environmental impacts to soils occurring within the analysis area. For soils, the analysis area includes all land within the boundaries of the 65 leases under consideration. The site-specific use and management of soil types within each area to be disturbed during the development of each lease would be evaluated during the Application for Permit to Drill process. In order to develop a lease on lands administered by the Forest Service, the lessee is required to submit an Application for Permit to Drill to the BLM and Surface Use Plan of Operations to the Forest Service. Site-specific National Environmental Policy Act (NEPA) analyses would be required at this stage and may include detailed soils investigations and analyses. Additionally, the Forest Service may require Conditions of Approval that would mitigate or reduce impacts to soil resources or minimize the effects of soil characteristics that limit soil stability and reclamation.

A variety of soils occur across the analysis area. The soil variability stems primarily from a variety of parent materials and the influence of topography, aspect, elevation, vegetation, and differential rates of mineral weathering. The soils range in depth from very deep (60 inches or more in valley bottoms) to shallow (on ridges and steep slopes). Refer to the WRNF Oil and Gas Leasing Final EIS for additional detail on the soils in the study area (USFS 2014a).

Water erosion is the detachment and movement of soil by water. Natural erosion rates depend on inherent soil properties, slope grade and length, soil cover, and climate. Erosion also may be influenced by the length of time the soils are bare and by alteration of drainage and erosion control structures. Erosion caused by water occurs primarily on loose, non-cohesive soils on moderate to steep slopes, particularly during high intensity storm events. The erodibility factor of the whole soil, including fine particles and stones (Kw), is a measure of the potential for bare soil detachment by runoff and raindrop impact. The soil erodibility factor can range from 0.02 to 0.64, and the higher the number, the greater the hazard. For the purposes of this analysis, water erosion prone soils were determined to have a Kw factor greater than or equal to 0.27. The distribution of soils with high erodibility is shown in **Figure 3.4-2**. **Table 3.4-1** provides the acres (and percentage) of water erodible soils within each zone.

Wind erosion is the physical wearing of the earth's surface by wind. Wind erosion removes and redistributes soil. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture, frozen soil layers, surface fragments (rock, duff, litter), slope and other factors also may influence erosion.

Y:\GIS\Projects\BLM_WhiteRiver_OG_EIS_60332451\FIGS\DOC\1_PDEIS\FIG_3_4_1_Soils_MLRA.mxd



Date: 9/17/2015

Figure 3.4-1 Major Land Resource Areas

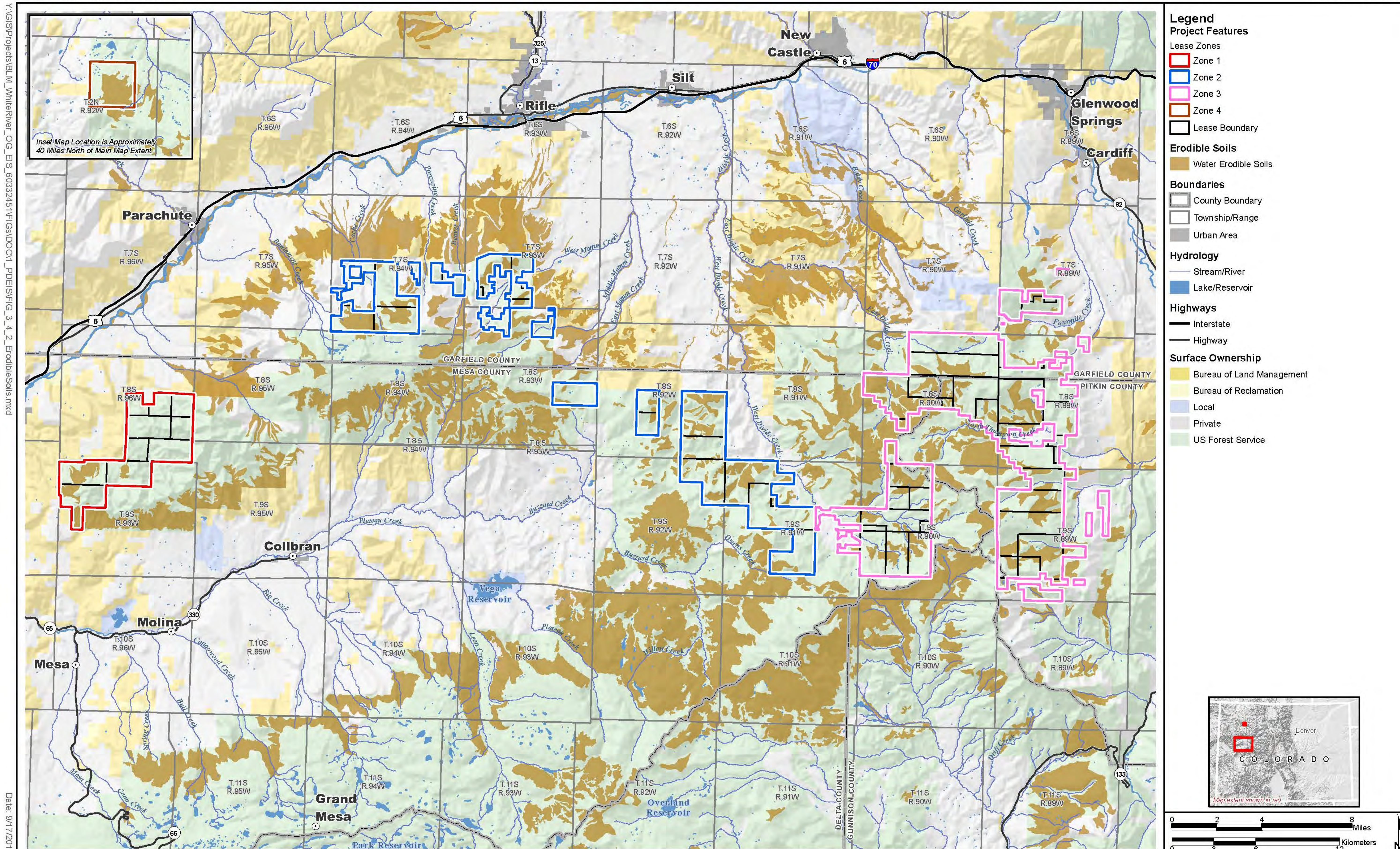


Figure 3.4-2 Soils Susceptible to Water Erosion

Soil characteristics, such as susceptibility to erosion, are important to consider when planning for construction activities, best management practices to minimize erosion, and stabilization of disturbed areas. Such soil characteristics, in combination with the climate and vegetation, may increase the risk of hazards. The extent of water erodible soils are presented in further detail by zone and lease in the following sections.

Table 3.4-1 Water Erodible Soils by Zone

Zone	All Soils (acres)	Water Erodible Soils (acres)	Water Erodible Soils (% of Zone)
1	10,114	1,311	13
2	24,938	7,309	29
3	42,767	12,565	29
4	2,562	1,176	46

3.4.4.1 Zone 1

Within Zone 1, approximately 1,311 acres of soil map units are identified as being prone to water erosion. **Table 3.4-1** provides the map units and acreages of erodible soils. **Figure 3.4-1** illustrates the distribution of erodible soils within Zone 1.

3.4.4.2 Zone 2

Within Zone 2, approximately 7,309 acres of soil map units are identified as being prone to water erosion. **Table 3.4-1** provides the map units and acreages of erodible soils. **Figure 3.4-1** illustrates the distribution of erodible soils within Zone 2.

3.4.4.3 Zone 3

Within Zone 3, approximately 12,565 acres of soil map units are identified as being prone to water erosion. **Table 3.4-1** provides the map units and acreages of erodible soils. **Figure 3.4-1** illustrates the distribution of erodible soils within Zone 3.

3.4.4.4 Zone 4

Within Zone 4, approximately 1,176 acres, consisting of a single soil map unit, are identified as being prone to water erosion. **Table 3.4-1** provides the map units and acreages of erodible soils. **Figure 3.4-1** illustrates the distribution of erodible soils within Zone 4.

This page intentionally left blank