3 AFFECTED ENVIRONMENT

This PEIS provides an assessment of environmental, social, and economic issues at a programmatic level and not at the lease and project development level. The descriptions of the affected environment presented in this chapter do not provide detailed information about conditions at specific project locations. These descriptions provide the level of detail needed to assess the types of possible impacts that may occur because of potential oil shale or tar sands resource leasing and development on BLM-administered lands.

3.1 LAND USE

This section describes the wide range of land uses that occur on BLM-administered lands and other lands within the study area. General information about the management of BLM-administered lands is presented in the context of each BLM field office and administrative unit that has jurisdiction over the oil shale and tar sands resources evaluated in this PEIS. Additional information is presented about other federal lands that coincide with oil shale and tar sands resources, and general information is presented about the use of other federal and state lands in the area. A description of the management of BLM-administered lands is presented in Section 2.2.3.

Decisions within this PEIS apply only to lands administered by the BLM. Tables 2.3-1 and 2.4-1 in Chapter 2 identify the total acreage included within the study area for the PEIS. The total acreage included in the most geologically prospective areas for oil shale and tar sands (the STSAs) is approximately 4.5 million surface acres. The BLM administers approximately 2.7 million surface acres of this total, or approximately 60%. The remaining 40% of acres are owned by states, tribes, local governments, and private individuals and corporations, or are administered by other federal agencies (e.g., the USFWS and NPS). These lands are interspersed throughout the study areas, and activities on all of these lands have the potential to affect lands owned or managed by others. Figures 2.3.3-1, 2.3.3-2, and 2.3.3-3 in Chapter 2 illustrate how these lands are interspersed. Privately owned lands within the study areas total approximately 870,000 acres or 19%. Much of the privately owned land derived from the operation of the many and varied federal public land laws that were designed and intended to facilitate settlement of the West. The pattern of private ownership tends to concentrate along rivers, streams, and other sources of perennial water; at the intersections of historical travel routes; and in areas of more fertile farm and ranch lands. Both historically and today, private lands and communities have had strong economic, cultural, and social ties to the federally managed lands that surround them. Uses on these federal lands are of extremely high interest to local communities and also, increasingly, to populations that are far removed from them.

3.1.1 BLM Land Use Plans within the Study Area

Table 3.1.1-1 lists the BLM field offices and administrative units with jurisdiction over areas containing the oil shale and tar sands resources evaluated in this PEIS. The table includes

TABLE 3.1.1-1 BLM Field Offices and Administrative Units, Existing Land Use Plans, and Estimated Surface Acreages Overlying the Most Geologically Prospective Oil Shale Resources and STSAs

		Estimated Surface Overlying the Resources (acres)[a]			
		Oil Shale		Tar Sands	
Field Office	Existing Land Use Plan	BLM	Split Estate[b]	BLM	Split Estate[b]
Colorado					
Colorado River Valley[c]	Glenwood Springs RMP (BLM 1988, as amended by the Roan Plateau Plan Amendment [BLM 2007a, 2008a])	10,442	3,715	0	0
Grand Junction	Grand Junction RMP (BLM 1987a)	181	3,843	0	0
White River	White River RMP (BLM 1997a, as amended by the Roan Plateau Plan Amendment [BLM 2007a, 2008a])	309,086	34,382	0	0
Colorado total		319,710	41,940	0	0
Utah					
Grand Staircase–Escalante National Monument[d]	Grand Staircase–Escalante National Monument Management Plan (BLM 1999a)	0	0	51,226	6,707
Monticello	Monticello RMP (BLM 2008f)	0	0	8,050	0
Price	Price RMP (BLM 2008e)	107	0	194,324	18,575
Richfield	Richfield RMP (BLM 2008i)	0	0	83,040	0
Vernal[e,f]	Vernal RMP (BLM 2008d)	560,864	77,220	237,717	56,866
Utah total		560,972	77,220	574,357	82,148
Wyoming					
Kemmerer	Kemmerer RMP (BLM 2010a)	221,358	2,313	0	0
Rawlins	Rawlins RMP (BLM 2008c)	80,492	0	0	0
Rock Springs[c]	Green River RMP (BLM 1997b, as amended by the Jack Morrow Hills Coordinated Activity Plan [BLM 2006b])	955,829	37,093	0	0
Wyoming total		1,257,680	39,406	0	0

Footnotes on next page.

TABLE 3.1.1-1 (Cont.)

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[a] Estimated acreages were calculated from GIS data compiled to support the PEIS analyses.

[b] Split estate lands include areas where the federal government owns, and the BLM administers, the subsurface mineral rights, but the surface estate is owned by tribes, states, or private parties.

[c] Planning efforts are underway to revise or replace the plan(s) in this field office.

[d] Although lands within the GSENM would be excluded from future leasing for tar sands development, they are included in this table because they overlie the Circle Cliffs STSA. Potential commercial tar sands leasing and development in the GSENM, however, is not assessed in the PEIS.

[e] A portion of the P.R. Spring STSA extends south from the Vernal Field Office boundary into the Moab Field Office boundary; however, this area is administered by the Vernal Field Office under an MOU with the Moab Field Office. Under this agreement, the Vernal Field Office administers all resources and programs, including land use planning, for the entire P.R. Spring STSA. Therefore, the Moab Field Office plan is not impacted by this PEIS.

[f] Split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation coincide with oil shale and tar sands resources in the Vernal Field Office. The split estate acreage estimate for oil shale in the Vernal Field Office includes approximately 57,705 acres of lands within the Hill Creek Extension. The split estate acreage estimate for tar sands in the Vernal Field Office includes approximately 35,472 acres of lands within the Hill Creek Extension.

the names of the existing land use plans and estimates of the total acreage of BLM-administered and split estate lands that coincide with the most geologically prospective oil shale areas and STSAs being evaluated in this PEIS. As discussed in Section 1.4.3, management decisions contained in these existing BLM land use plans have been incorporated into the analyses conducted in this PEIS. In turn, the ROD resulting from the final PEIS may amend these land use plans to incorporate management decisions related to making land available or not available for application for commercial leasing and development of oil shale and tar sands resources. Figure 3.1.1-1 shows the distribution of public lands administered by the BLM within the region where the oil shale and tar sands resources are located.

The following sections provide an overview of each administrative unit that falls within the PEIS study area and the corresponding land use plan(s). Information about ongoing planning activities and the status of each land use plan is presented. In addition, information about specially designated areas and land uses (e.g., energy and mineral development activities, grazing, recreational use, and ROW authorizations) is presented for those areas that coincide with the oil shale or tar sands resources or could be impacted by their commercial leasing and development. Some of these activities, such as grazing and recreational use, are widespread and dispersed across all planning areas. Similarly, ROW authorizations are extensive in some planning areas. The information presented in these sections is not exhaustive; individual land use plans provide more complete descriptions of land use.

3.1.1.1 Colorado River Valley Field Office, Colorado (formerly the Glenwood Springs Field Office)

The Glenwood Springs RMP (BLM 1984) was first issued in 1984 and included the most geologically prospective oil shale area within the Colorado River Valley Field Office that is of interest in this PEIS. This plan was amended numerous times through 2007; at that point, almost all of the most geologically prospective oil shale area was included in the Roan Plateau RMP Amendment that was completed in 2007 and amended in 2008. Some of the amendments to the Glenwood Springs RMP are still relevant and are discussed below. The BLM administers approximately 66,934 surface acres and 73,602 acres of mineral estate within the planning area encompassed by the Roan Plateau RMP Amendment (Figure 3.1.1-2). The oil shale resources are located within the Piceance Basin; no tar sands resources are located within the jurisdiction of this field office. The Oil Shale and Tar Sands PEIS and ROD made land use plan decisions regarding areas available for application for oil shale leasing within the field office.

Most of the oil shale resource included in the most geologically prospective area within the field office is included in the Naval Oil Shale Reserves (NOSRs) Nos. 1 and 3, which were transferred from the DOE to BLM administration pursuant to the Department of Defense Authorization Act of 1998 (P.L. 105-85). NOSRs 1 and 3 are also completely contained within the Roan Plateau Planning Area. A total of 55,354 acres of land were involved in the transfer, including 36,362 acres in NOSR 1 and 18,992 acres in NOSR 3. The Act required the DOI to make these lands available for leasing for oil and gas development, and stipulated that leasing occur within the developed tract of NOSR 3 within 1 year. The 1999 RMP amendment (BLM 1999b) addressed leasing on 12,029 acres of land within NOSR 3. The Roan Plateau RMP

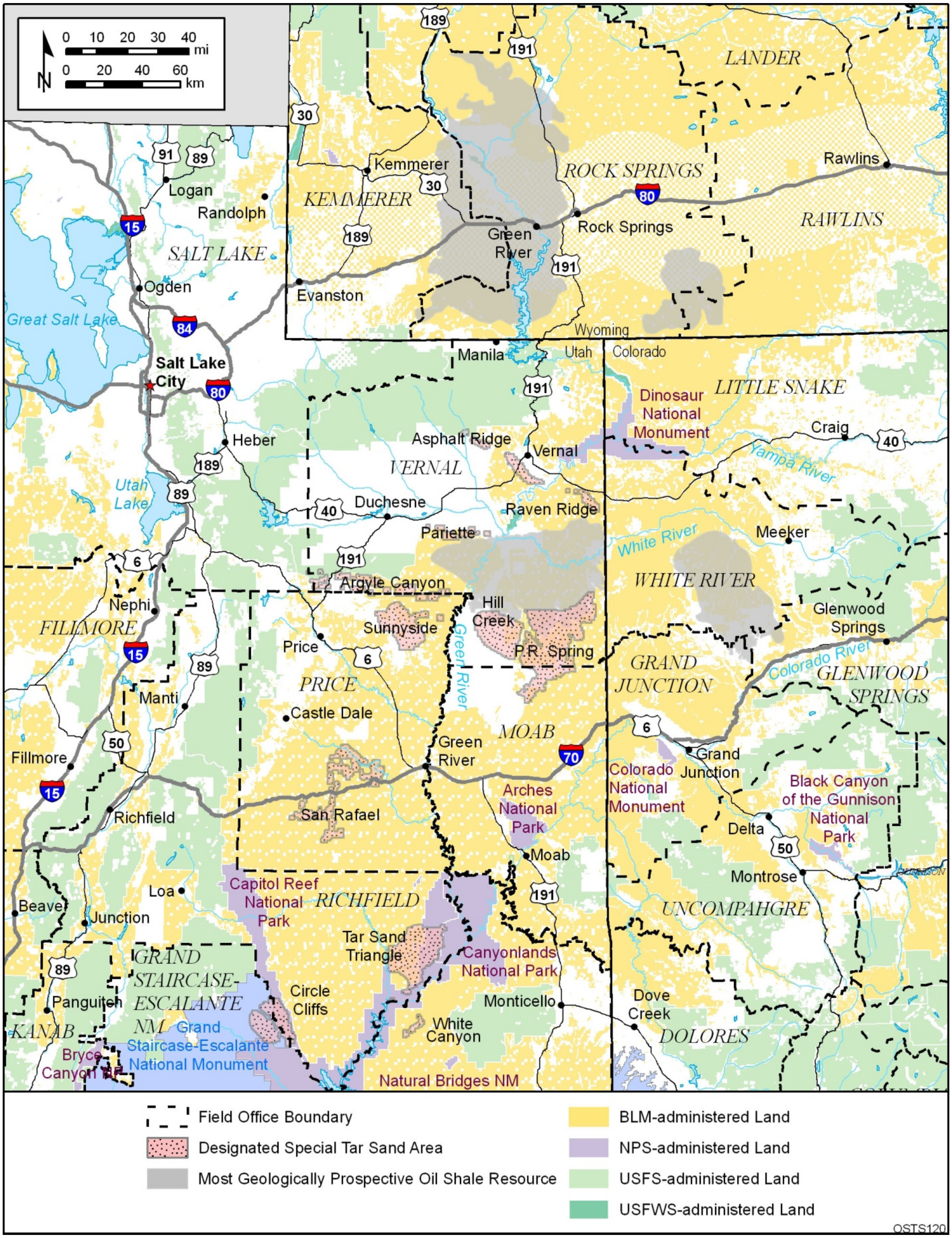

FIGURE 3.1.1-1 Distribution of BLM-, NPS-, USFS-, and USFWS-Administered Lands with Respect to Oil Shale and Tar Sands Resources

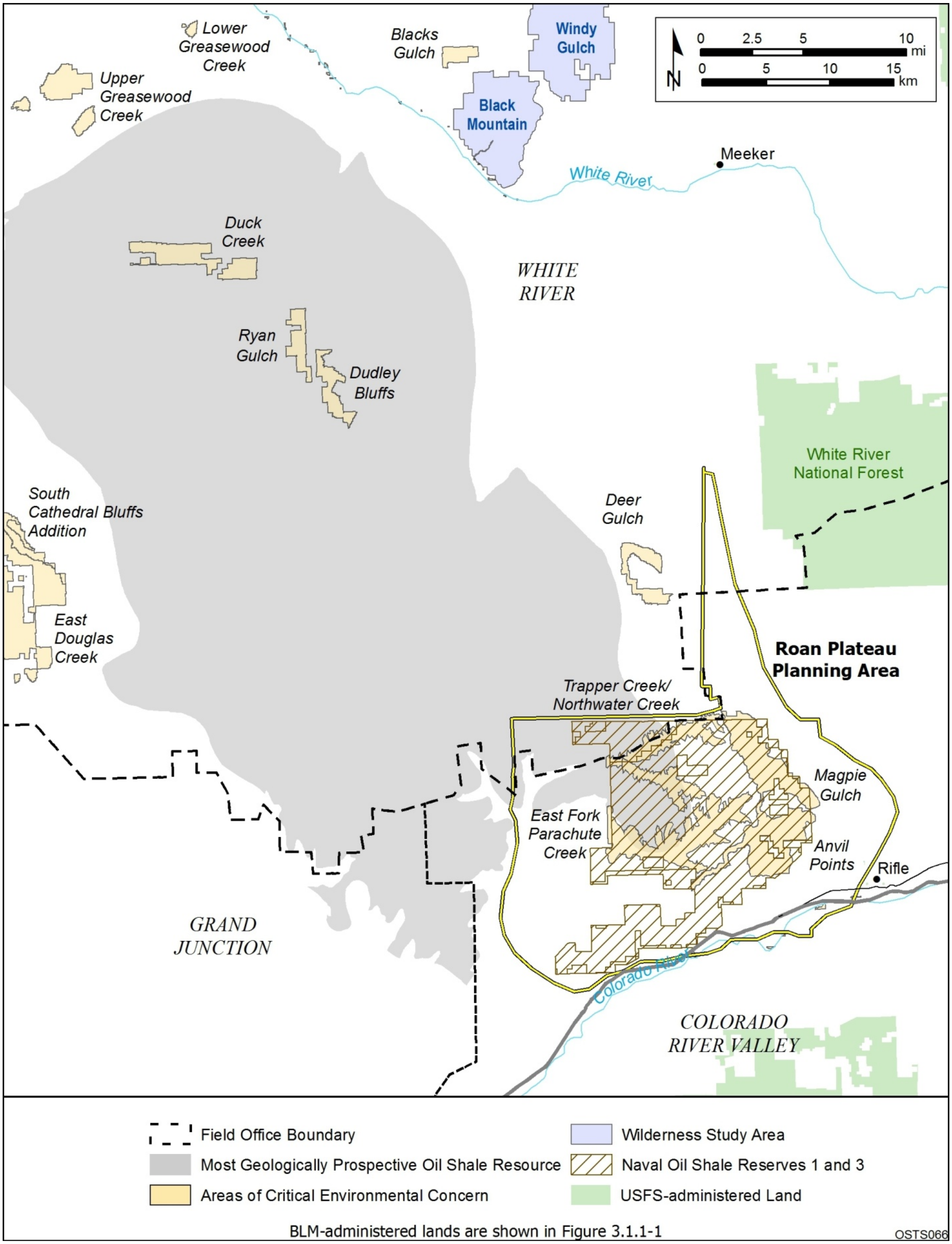

FIGURE 3.1.1-2 BLM Planning Areas in Colorado Where Oil Shale Resources Are Located

Amendment, for which a Final EIS was issued in 2006 (BLM 2006a), was prepared to develop an integrated management strategy that incorporates the transferred NOSRs into the remainder of BLM-administered land in the planning area and establishes a unified set of goals, objectives, and land use or management actions. The RMP amendment, which was approved by an ROD issued in 2007 (BLM 2007a) and one issued in 2008 (BLM 2008a), establishes the Roan Plateau Planning Area as an area of 127,007 acres, encompassing NOSRs 1 and 3 (55,354 acres), other BLM-administered lands (18,248 acres of federal surface and split estate lands), and nonfederal lands (53,405 acres) (Figure 3.1.1-2). The 2008 amendment to the Roan Plateau RMP amendment established new ACECs within the plan area. While a portion of the Roan Plateau Planning Area extends into the White River Field Office boundary, the Colorado River Valley Field Office will have jurisdiction over management of the entire planning area.

The 2008 Oil Shale and Tar Sands (OSTS) PEIS and ROD made land use plan decisions regarding areas available for application for oil shale leasing within the field office. The 2008 OSTS ROD erroneously proposed opening the lands in NOSRs 1 and 3 to oil shale leasing; however, the lands were not opened, as there is a withdrawal on the transferred lands that prevents the lands from being leased for oil shale development, and no opening order has been issued. Consequently, in the current PEIS, that error is being corrected and the areas within the NOSR will be correctly identified as being unavailable for application for commercial oil shale leasing. A small portion of the NOSR extends into the White River Field Office, and that portion of the oil shale resource is also unavailable for application for oil shale leasing. Another small portion of the oil shale resource that is within the Colorado River Valley Field Office but west of the NOSR would continue to be available for application for leasing under the No Action Alternative.

In 2001, the Glenwood Springs RMP was amended to support revocation of existing withdrawals, with the exception of NOSRs 1 and 3, of deposits of oil shale and public lands containing such deposits from leasing or other disposal—these withdrawals had been put in place in order to protect the oil shale resource pending further study and classification (BLM 2001a). The withdrawals were no longer considered necessary because existing regulations, policies, and land use decisions were adequate to manage the oil shale resources.

Other energy and mineral development on lands managed by the Colorado River Valley Field Office includes oil and gas, and coal. In the 1988 RMP, most of the lands in the field office region were designated as open to mineral leasing and development. Oil and gas are the principal resources overlapping the oil shale resources being evaluated in this PEIS. In 1991 and again in 1999, in response to increased oil and gas development activities, the RMP was amended to facilitate orderly, economic, and environmentally sound exploration and development of these resources. Under the 1999 amendment (BLM 1999b), lands within WSAs (27,760 acres) were closed to all oil and gas leasing. In addition, No Surface Occupancy (NSO), Timing Limitation (TL), and Controlled Surface Use (CSU) stipulations were identified to be attached to oil and gas leases to protect specific areas or resources, such as riparian and wetlands areas, rivers, sensitive species, viewsheds, and watersheds.

The Colorado River Valley Field Office administers grazing on allotments that cover a significant portion of the planning area. Recreation sites have been established in areas of heavy recreational use; larger areas of dispersed but heavy recreational use have been identified and designated as SRMAs. None of the designated recreation sites or SRMAs are located in areas overlying the oil shale resources being evaluated in this PEIS. ROW authorizations exist within the planning area and may be in an area that could be affected by oil shale leases.

Several WSAs have been designated in the planning area; however, they are located in the eastern part of the area, away from the oil shale resources. There were areas identified by the BLM in the Roan Plateau Planning Area as containing wilderness characteristics, but the decision was made in the 2007 ROD that these areas would not be specifically managed to maintain these wilderness characteristics. A A number of ACECs have been designated within the Colorado River Valley Field Office boundary (Figure 3.1.1-2). Four of these ACECs are located within the Roan Plateau Planning Area, as defined in the Roan Plateau Plan Amendment (BLM 2006a).[1] Two of them overlap with the oil shale resources being evaluated in this PEIS (Table 3.1.1-2). In addition, the Roan Plateau Plan Amendment and ROD (BLM 2006a, 2007a) established the Parachute Creek Watershed Management Area, encompassing an area of 33,575 acres, on top of the plateau that overlaps a portion of the most geologically prospective oil shale resource. Stipulations restricting surface-disturbance activities have been established in the Roan Plateau RMP Amendment for portions of these ACECs and for the watershed management area (BLM 2006a, 2007a, 2008a). Other ACECs within the Roan Plateau planning area do not overlap with oil shale resources.

The BLM has identified rivers and corridors within the Roan Plateau Planning Area as being eligible for designation as WSRs (BLM 2006a). Portions of the eligible Trapper Creek, Northwater Creek, and East Fork Parachute Creek, shown in Figure 3.1.1-2, overlie the oil shale study area.

3.1.1.2 Grand Junction Field Office, Colorado

The Grand Junction RMP (BLM 1987a) was first issued in 1987 and has been amended numerous times. The Grand Junction Field Office is in the process of revising the Grand Junction RMP. The BLM administers approximately 1.2 million acres within the planning area encompassed by this RMP; however, only a small portion of the planning area overlaps with the oil shale resources evaluated in this PEIS (Figure 3.1.1-2). The oil shale resources are located within the Piceance Basin; no known tar sands resources are located within the boundaries of this field office. The 2008 OSTS PEIS and ROD made land use plan decisions regarding areas available for application for oil shale leasing within the field office.

In 2001, the Grand Junction RMP was amended to support revocation of previous withdrawals of deposits of oil shale and public lands containing such deposits from leasing or other disposal. Such withdrawals had been in place in order to protect the oil shale resource, pending further study and classification (BLM 2001a). The withdrawals were no longer

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[1] The Roan Plateau ROD issued in 2007 approved only portions of the proposed plan amendments in BLM 2006a. A second ROD finalizing establishment of these ACECs was completed in 2008 (BLM 2008a).

TABLE 3.1.1-2 Colorado River Valley Field Office ACECs That Overlap with Oil Shale Resources

ACEC	R&I Criteria[a]	Acreage[b]
East Fork Parachute Creek	Scenic values, fisheries, and plant resources	6,571
Trapper/Northwater Creek	Fisheries and plant resources	4,810

[a] R&I = relevance and importance.

[b] Acreage estimates represent the entire unit (not just the portion overlying the oil shale resources) and were derived from the Roan Plateau RMP Amendment (BLM 2008a).

considered necessary because existing regulations, policies, and land use decisions were adequate to manage the oil shale resources.

Oil and gas and mineral development activities occur within the Grand Junction RMP boundary on both public and nonfederal lands. About 8% of the planning area is closed to oil and gas leasing; of the remaining area, almost 43% is open to leasing with standard lease terms, 9% has NSO stipulations, and the remaining 38% has other stipulations attached to leasing. Approximately 390,000 acres of the Book Cliffs potential coal development area are considered acceptable for further coal leasing consideration. The Palisade municipal watershed and the Colorado River corridor through DeBeque Canyon are closed to coal development.

Other principal uses of public land within the boundary of the field office include grazing and recreation. Recreational use is varied and dispersed throughout the planning area. A number of areas are managed as SRMAs; however, none of them coincide with the oil shale resources evaluated in this PEIS. ROW authorizations exist within the planning area and may be co-located with the oil shale resources.

Several WSAs and ACECs are located within the planning area; however, none of these areas overlap with the oil shale resources. The McInnis Canyons NCA, managed by the BLM, and Colorado National Monument, managed by the NPS, are located within the Grand Junction Field Office boundary, but both are more than 35 mi from the oil shale resources being evaluated in this PEIS.

3.1.1.3 White River Field Office, Colorado

The White River RMP was first issued in 1997 (BLM 1997a) and has been amended several times. An amendment addressing oil and gas issues is currently in preparation and a draft is scheduled for release in the fall of 2012. The BLM administers approximately 1.46 million acres of surface estate and an additional 365,000 acres of split estate lands within the planning area encompassed by this RMP (Figure 3.1.1-2). The oil shale resources are located within the Piceance Basin, and the White River Field Office manages the bulk of the most geologically prospective oil shale resource in the Piceance Basin; no tar sands resources are located within the boundary of this field office. The 2008 OSTS PEIS and ROD made land use plan decisions regarding areas available for application for oil shale leasing within the field office.

In 2001, the White River RMP was amended to support revocation of previous withdrawals of deposits of oil shale and public lands containing such deposits from leasing or other disposal. Such withdrawals had been in place in order to protect the oil shale resource, pending further study and classification (BLM 2001a). The withdrawals were no longer considered necessary because existing regulations, policies, and land use decisions were adequate to manage the oil shale resources.

As discussed in Section 3.1.1.1, the Roan Plateau RMP Amendment and ROD (BLM 2006a, 2007a, 2008a) establish the Roan Plateau Planning Area as an area incorporating NOSRs 1 and 3, other BLM-administered lands, and nonfederal lands. A small portion of this new planning area overlaps with the White River Field Office. The amendment defines an integrated management strategy for the entire area, although management decisions are applicable only to the BLM-administered lands. While a portion of the Roan Plateau Planning Area extends into the White River Field Office boundary, the Colorado River Valley Field Office has jurisdiction over management of the entire planning area.

The White River RMP contained a number of decisions related to oil shale development in the Piceance Basin that were superseded by the ROD for the Oil Shale and Tar Sands PEIS in 2008. Decisions from the 1985 Piceance Basin RMP (BLM 1985b) that are still in effect in include the following: 70,820 acres are available for leasing for multimineral development (i.e., development of oil shale, nahcolite, and dawsonite) inside the identified Multimineral Zone (Figure 3.1.1-3); multimineral development will be allowed only if recovery technologies are implemented to ensure that each of these minerals can be recovered without preventing recovery of the others; and the issuance of leases for oil shale research activities is allowed for by the RMP. Five RD&D leases have been issued in the White River Field Office for the purpose of demonstrating the application of potential oil shale recovery technologies (see Section 2.3 and Figure 2.3-2).

There are two RD&D leases that recently completed NEPA analysis and have been approved in the White River Field Office.

Intensive oil and gas and other mineral development is occurring within the White River Field Office boundary on both public and nonfederal lands, and much of this development is coincident with the oil shale resources. More than 1.5 million acres of land are available for oil and gas leasing with special stipulations, and an additional 168,486 acres are available for leasing under standard lease terms. Oil and gas transport and feeder pipelines cross the oil shale resources evaluated in this PEIS.

Oil and gas development is projected to increase significantly on the lands managed by the White River Field Office. A number of projects are currently under consideration to expand

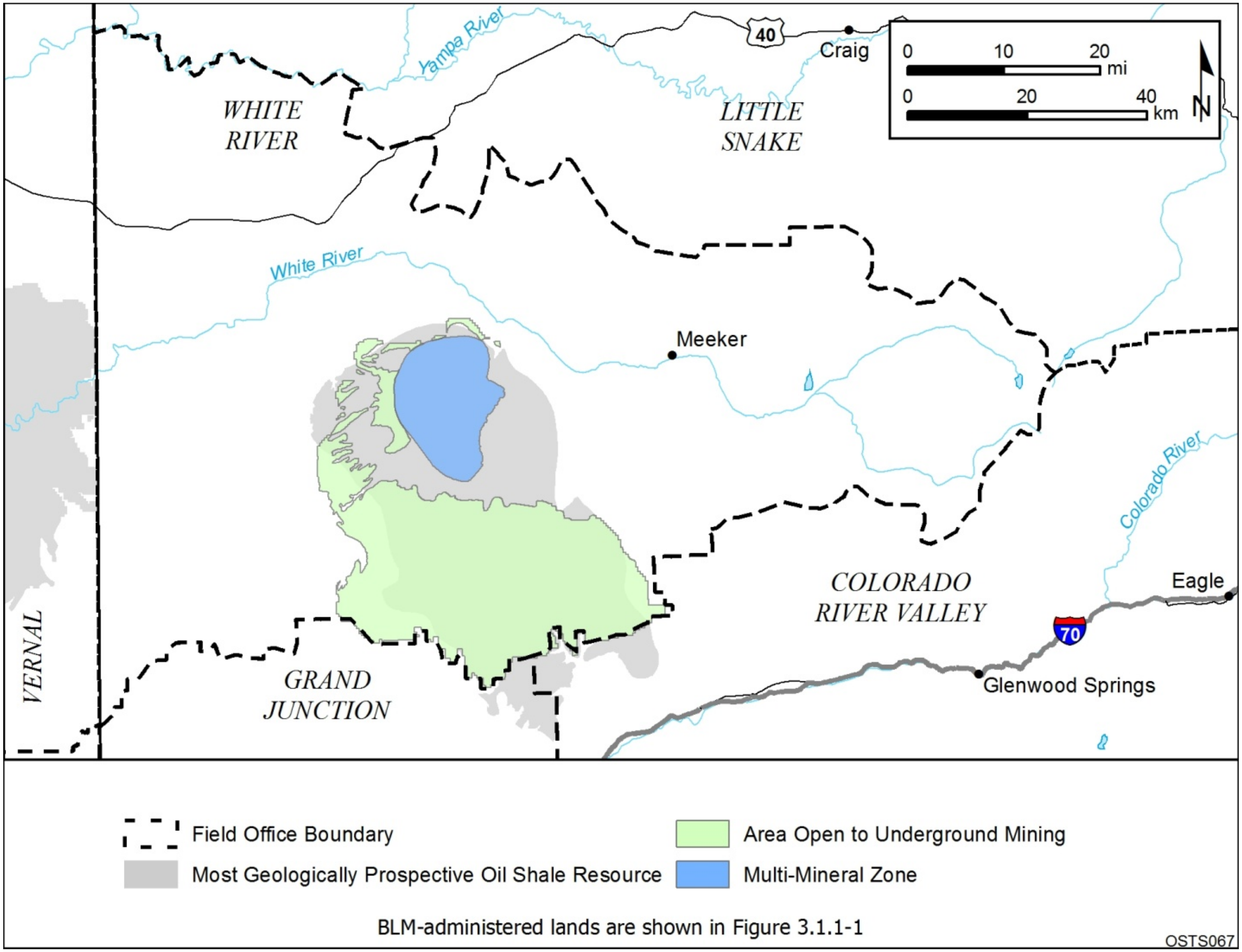

FIGURE 3.1.1-3 1997 White River RMP Decisions Related to Oil Shale Leasing and Development

existing development and the associated infrastructure. In June 2006, the BLM initiated preparation of an EIS to evaluate the proposed amendment of the existing RMP to address the potential impacts of significant increases in oil and gas development in the area. Preparation of this amendment is ongoing. In the last plan revision in 1997, the BLM anticipated the potential development of 1,100 oil and gas wells (at a rate of about 55 wells/yr), most of which were to be drilled south of Rangely, Colorado. In 2007, the oil and gas industry projected that more than 21,000 wells could be drilled in the planning area over the next 20 years (BLM 2007d).

The White River RMP states that 172,700 acres of land within the planning area are underlain by recoverable coal reserves; 11,470 acres were found to be unsuitable for coal mining; 43,380 acres were found to be suitable for underground mining only; and 117,850 acres were found to be suitable for both surface and underground mining. Approximately 610,000 acres are available for mining of locatable minerals.

The White River Field Office administers grazing on allotments that cover a significant portion of the planning area, including the area where the oil shale resources are located. The entire field office area has been designated as the White River Extensive Recreation Management Area; no SRMAs have been designated. The Piceance-East Douglas Herd Management Area (HMA) overlaps with the oil shale resources (see Section 3.1.3 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the oil shale resources.

Several WSAs have been designated within the White River Field Office area; however, they are all located to the northeast and northwest of the oil shale resources being evaluated in this PEIS. There also are areas that have been identified that possess wilderness characteristics within the field office boundary, and five within the most geologically prospective area for oil shale development. A number of ACECs have been designated within the White River Field Office boundary. Figure 3.1.1-2 shows those located within the most geologically prospective area for oil shale. The ACECs that overlap with the oil shale resources being evaluated in this PEIS are listed in Table 3.1.1-3. One of these ACECs, the Trapper/Northwater Creek ACEC, is located within the Roan Plateau Planning Area.

A portion of Dinosaur National Monument, which is managed by the NPS, falls within the White River Field Office boundary; however, it does not overlie any of the oil shale resources being evaluated in this PEIS (Figure 3.1.1-2). At its closest point, the Monument is more than 25 mi from the oil shale resources being evaluated within the Piceance Basin.

An underground nuclear test site, the Rio Blanco site, is also located in the Piceance Basin, White River Field Office area. The 360-acre site on DOE-administered land located approximately 30 mi southwest of Meeker was the site of nuclear testing in 1973. Three 30-kiloton nuclear devices were detonated simultaneously at the bottom of shafts more than 1 mi deep. This site is not included as part of the study area because the area is not on BLM-administered land. Because the detonations took place in low-permeability, low-transmissivity shale and claystone formations with sandstone lenses, test-related radionuclides are not expected to travel far from the source area. Ongoing monitoring conducted at this DOE Legacy site shows no surface contamination, and there are no surface use restrictions at the site. However,

TABLE 3.1.1-3 White River Field Office ACECs That Overlap with Oil Shale Resources

ACEC	R&I Criteria	Acreage[a]
Duck Creek	Threatened and endangered plant and cultural resources	3,430
Ryan Gulch	Threatened and endangered plant resources	1,440
Dudley Bluffs	Threatened and endangered and sensitive plant resources	1,630
Trapper	Fisheries and plant resources	4,810[b]

[a] Acreage estimates represent the entire unit (not just the portion overlying the oil shale resources) and were derived from the White River RMP (BLM 1997a) unless otherwise noted.

[b] Acreage estimates were derived from the Roan Plateau RMP Amendment (BLM 2006a).

subsurface disturbance is not allowed within a 600-ft radius of the test area without U.S. government permission. Groundwater and surface water monitoring have shown no radiological contamination. The Green River Formation lies about 3,000 ft above the depth where the detonations occurred. If the BLM were to lease its bordering property for oil shale development in the future, stipulations would be included to confirm that no radioactive contaminants would be mobilized.

3.1.1.4 Grand Staircase–Escalante National Monument, Utah

The GSENM was established by Presidential Proclamation in September 1996. The GSENM Management Plan, published as proposed in 1999, became effective in February 2000 (BLM 1999a). The GSENM encompasses about 1.87 million acres of federal lands and is surrounded primarily by federal lands, including the Dixie National Forest, Capitol Reef National Park, Glen Canyon NRA, Bryce Canyon National Park, and other BLM-administered lands (Figure 3.1.1-4). The GSENM overlies the western portion of the Circle Cliffs STSA. The eastern portion of this STSA extends into Capitol Reef National Park. According to available maps, a small portion of the Circle Cliffs STSA extends to the south into the Glen Canyon NRA. No oil shale resources are located within the Monument.

Currently, 8,921.36 acres within the Circle Cliffs STSA are held under two pending conversion leases for tar sands development (see Section 1.4.2). When the GSENM was established, all federal lands and interests within the Monument were withdrawn from additional entry, location, selection, sale, leasing, or other disposition, including mineral leasing. No new federal mineral leases can be issued, nor can new mining claims be located within the Monument. However, a number of oil and gas leases, mineral leases, and mining claims were in place at the time the Monument was established. While there are 68 federal mining claims covering about 2,700 acres and 85 federal oil and gas leases covering more than 136,000 acres, the BLM will verify whether "valid existing rights" are present on a case-by-case basis

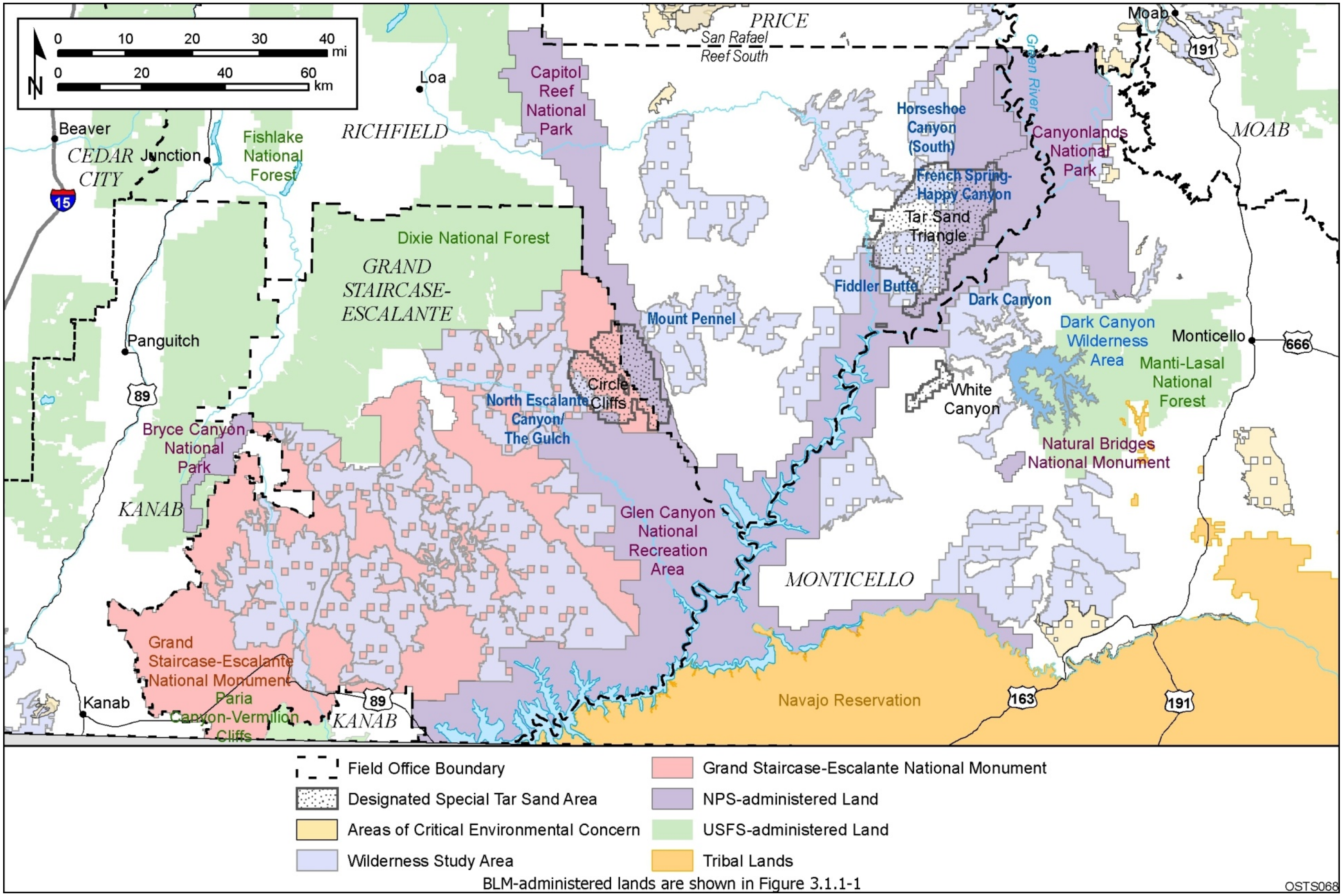

FIGURE 3.1.1-4 Portions of the Grand Staircase–Escalante National Monument and the Monticello and Richfield Field Offices Where Tar Sands Resources Are Located

(BLM 1999a). This adjudication process to determine the valid existing rights for pending conversion leases in the Circle Cliffs STSA is currently under way.

Some of the lands within the GSENM are designated as WSAs. Of these, the North Escalante Canyons/Gulch Instant Study Area (ISA) overlaps with the southwestern portion of the Circle Cliffs STSA (Figure 3.1.1-4), encompassing some of the lands included in the pending conversion leases. These lands fall within the Primitive Zone that has been designated within the GSENM; this zone is designated to provide visitors undeveloped and primitive experiences without motorized and mechanized access (BLM 1999a). A portion of the Circle Cliffs STSA, including lands within pending conversion leases, falls within the Outback Zone designated within the GSENM; this zone is designated to provide visitors undeveloped and primitive experiences while accommodating motorized and mechanized access (BLM 1999a). There are no ACECs designated within the GSENM.

3.1.1.5 Monticello Field Office, Utah

The Monticello RMP was issued in 2008, replacing a 1991 RMP. The 2008 OSTS PEIS and ROD made land use plan decisions regarding areas available for application for tar sands leasing within the field office.

The BLM administers more than 1.7 million acres of surface estate and an additional 763,000 acres of split estate lands within the planning area encompassed by this RMP (Figure 3.1.1-4). Tar sands are located in the field office within the White Canyon STSA; no oil shale resources are located in the lands managed by this field office.

According to the *Monticello Field Office Mineral Potential Report* (BLM 2006c), the other energy and mineral resources with a history of interest and development include oil and gas, coal, potash and salt, uranium-vanadium, copper, placer gold, sand and gravel, clay, and stone. Most of these resources, however, are not located in proximity to the White Canyon STSA. Unless otherwise noted, the following information about energy and mineral resources is from BLM (2006c).

The BLM administers more than 576,000 acres of federal leases for oil and gas development, including leases within the Glen Canyon NRA, Manti-LaSal National Forest, Navajo Indian Reservation, Indian Trust Lands, and split estate lands (BLM 1991b). Approximately 508 oil or gas wells are currently in production within the Monticello Planning Area (Vanden Berg 2005). This oil and gas development is located in the eastern portion of the planning area.

Coal deposits exist in the eastern portion of the field office region and were mined for several decades for local consumption. However, at this time there are no active coal mines. This is attributed to the low quality, thinness, and low heat value of the deposits. While potash and salt deposits are extensive across the eastern portion of the planning area, the only Known Potash Leasing Areas are in the northeastern corner of the field office region. Regarding the locatable minerals, uranium-vanadium, copper, and gold deposits and related mining claims occur within the Monticello Field Office, some in proximity to the White Canyon STSA. Salable Mineral Disposal Areas (for sand, gravel, clay, etc.) also have been established in the field office, but not in proximity to the White Canyon STSA.

The Monticello Field Office administers grazing on allotments that cover a significant portion of the planning area. Recreational use is varied and dispersed throughout the planning area. None of the designated recreation sites or SRMAs are located in areas overlying the tar sands resources in the White Canyon STSA. ROW authorizations exist within the planning area and may be co-located with the White Canyon STSA.

Several WSAs are located in the general vicinity of the White Canyon STSA. The Dark Canyon WSA lies adjacent to the STSA to the northeast and the Mancos Mesa and Cheesebox Canyon WSAs are located within 8 to 10 mi of the STSA (Figure 3.1.1-5). Available maps indicate that the Dark Canyon WSA may overlap with the STSA in a very small area.

As part of the development of the 2008 RMP the field office reviewed non-WSA areas with wilderness characteristics and made decisions regarding management of these areas. Five areas totaling about 88,781 acres have been identified to be managed to protect these wilderness characteristics. None of these areas intersect with the White Canyon STSA; however, the STSA contains and is surrounded by areas identified by the BLM as having wilderness characteristics that were not identified for long-term management to protect wilderness characteristics.

The BLM also has designated seven ACECs encompassing 73,492 acres within the field office, none of which are located near the White Canyon STSA.

The Monticello RMP also designated SRMAs that provide for management of various types of recreation uses. A portion of the White Canyon SRMA is located in the STSA and the Dark Canyon SRMA is located at the northeastern end of the STSA (Figure 3.1.1-5).

Other lands with special designations are located within the boundaries of the Monticello Field Office. NPS lands in the vicinity of the White Canyon STSA include Natural Bridges National Monument and portions of the Glen Canyon NRA and Canyonlands National Park. The nearest boundary of the Glen Canyon NRA is about 2 mi from the STSA boundary. The Manti-La Sal National Forest and the Dark Canyon Wilderness Area are located about 8 mi to the east of the White Canyon STSA (Figure 3.1.1-5).

3.1.1.6 Price Field Office, Utah

Resources on public lands in the Price Field Office are managed in accordance with the Price Resource Area RMP and ROD, which was completed in 2008 (BLM 2008g). This RMP replaced two previous plans. In addition, the OSTS PEIS and ROD made land use plan decisions regarding areas within the field office available for application for oil shale and tar sands leasing.

The BLM administers about 2.5 million acres of surface estate and an additional area of about 2.7 million acres of split estate lands within this planning area (Figure 3.1.1-6). Tar sands

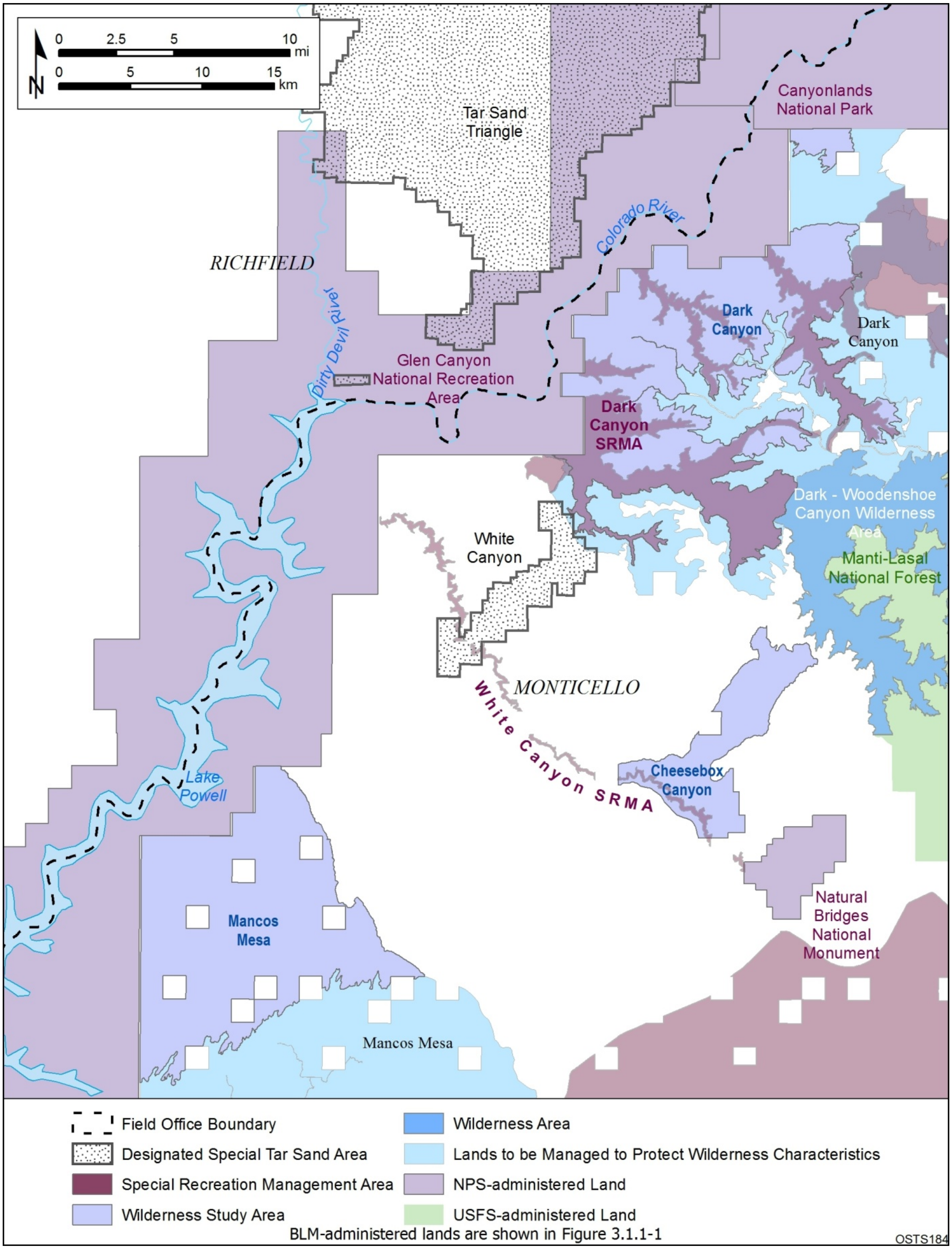

FIGURE 3.1.1-5 Specially Designated Areas in the Monticello Field Office in the Vicinity of the White Canyon STSA

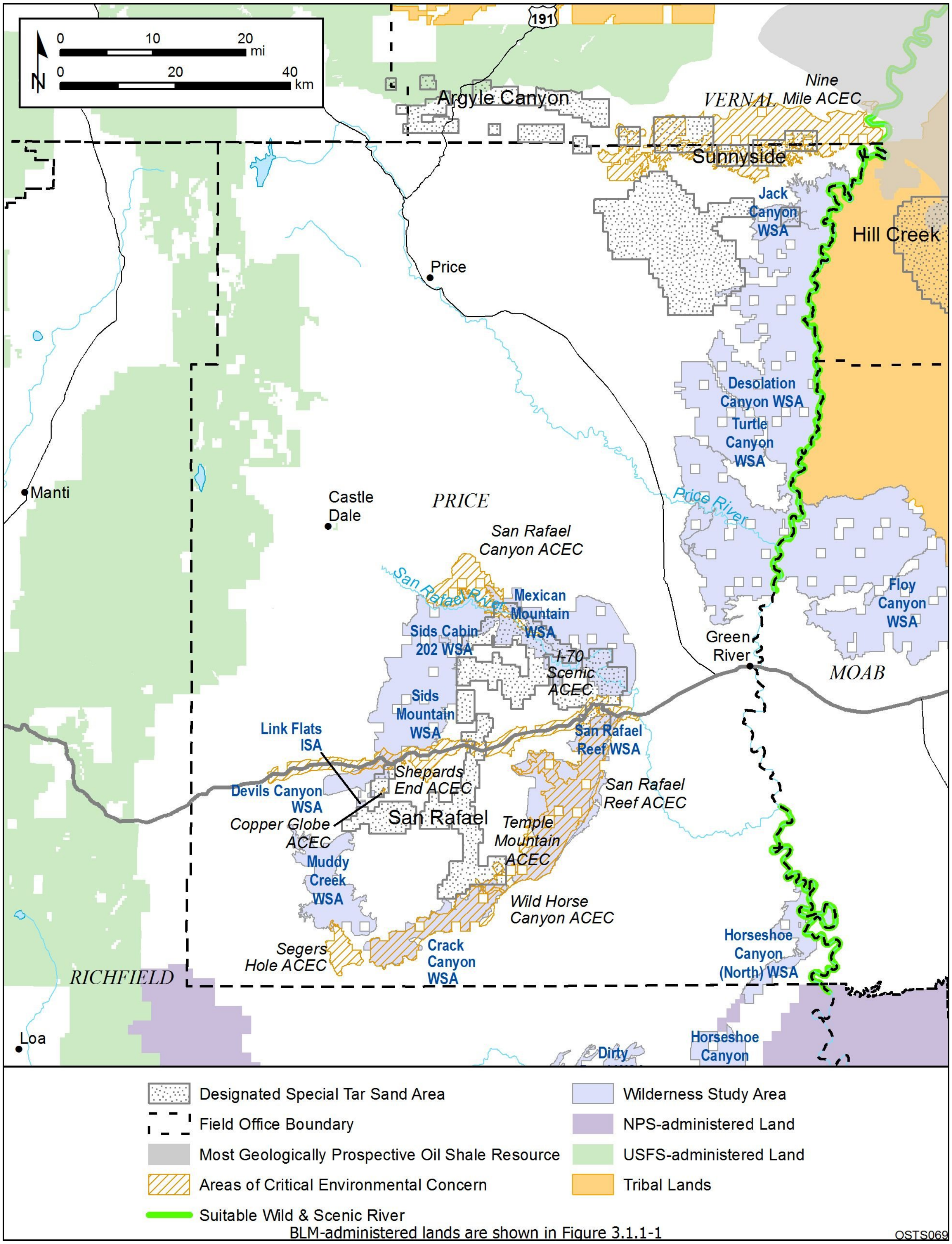

FIGURE 3.1.1-6 Price Field Office RMP Planning Area

are located within the San Rafael, Argyle Canyon, and Sunnyside STSAs; only a small portion (about 100 acres) of the most geologically prospective oil shale resources included in the study area falls within the jurisdiction of this field office. There are about 171,000 acres of additional, lower grade oil shale resources in the northeastern portion of the field office area. The STSAs and the most geologically prospective oil shale area have been classified as being available for application for commercial leasing.

According to the *Mineral Potential Report for Price Field Office, Carbon and Emery Counties, Utah* (BLM 2002a), the other energy and mineral resources that have been developed within the field office's region include oil and gas, coal, uranium, gypsum, potash and salt, sand and gravel, clay, and stone. Some of these resources are located in proximity to the STSAs.

Unless otherwise noted, the following information about energy and mineral resources is from BLM (2002a).

Approximately 1.9 million acres of land are available for oil and gas leasing with various levels of protective stipulations in the Price Field Office and about 569,000 acres are unavailable for leasing (Price Field Office ROD, BLM 2008g). There are no active leases in the vicinity of the San Rafael STSA and, while some portions of these lands are open to leasing under standard lease terms, other portions are closed to leasing for oil and gas development because they fall within WSA boundaries. The potential for future oil and gas development in the vicinity of the San Rafael STSA is considered to be low. A considerable number of active leases exist adjacent to the Sunnyside STSA, and this area is projected to have a high potential for development. Most of the lands around the Sunnyside STSA are leased, with seasonal or other minor constraints. Although currently there is no coalbed natural gas production in the vicinity of the Sunnyside STSA, the area is considered to have potential for future coalbed natural gas production within the Book Cliffs Coalbed Methane Play.

There are about 673,389 acres of land included in 106 coal leases on lands managed by the field office. None of these leases are located near the San Rafael STSA. Only a few areas are leased to the west of the Sunnyside STSA within the Book Cliffs coal field.

Mining claims include about 32,000 acres of land in the field office's region. Historic production of uranium has occurred in the vicinity of the San Rafael Swell in areas adjacent to the San Rafael STSA. Although continued development of this resource is considered unlikely over the next 15 years in the existing land use plans, there has recently been a very high interest in the development of uranium, as the price of this resource has increased. The prospects for other metal mining are relatively low throughout the field office area and in the vicinity of the STSAs. Production of gypsum, clay, sand and gravel, and stone has occurred in the vicinity of the San Rafael STSA or has the potential to occur in the future.

The Price Field Office administers grazing allotments on the basis of historical use and the availability of forage and water. These allotments cover the majority of the planning area and are categorized on the basis of their resource production potential and resource use conflicts. Most of the STSAs within the planning area coincide with grazing allotments. Seven SRMAs have been established within the planning area, some of which are near the STSAs, including the

Desolation Canyon, San Rafael Swell, Nine Mile Canyon, Cleveland Lloyd Dinosaur Quarry, and Range Creek SRMAs. The Muddy Creek, Sinbad, and Range Creek Wild Horse HMAs overlap with some of the tar sands resources, as does the Sinbad Wild Burro HMA (see Section 3.1.3 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be in areas with tar sands resources.

Several WSAs and ACECs have been designated in the Price Field Office. The WSAs and ACECs that overlap with an STSA and/or the most geologically prospective oil shale area are shown in Figure 3.1.1-6 and are listed in Table 3.1.1-4. The listed ACECs are those that were designated in 2008. Five sections of the Green River have been determined to be suitable for potential designation as a WSR (BLM 2008e). The two northern sections of the Green River overlie or are near oil shale and/or tar sands deposits and are shown in Figure 3.1.1-7.

There are 21 areas that were recognized by the BLM as having wilderness characteristics that overlie the San Rafael, Argyle Canyon, and Sunnyside STSAs, and the most geologically prospective oil shale area. As part of the Price RMP and ROD (BLM 2008g), decisions were made to manage five of these areas (totaling 97,100 acres) to protect, preserve, and maintain their wilderness character. The five areas are shown in Figure 3.1.1-7 and are discussed in greater detail in the supplement to the draft RMP (BLM 2007b). Four of these areas intersect with the San Rafael STSA (Table 3.1.1-5).

TABLE 3.1.1-4 Price Field Office WSAs and ACECs That Overlap with Tar Sands Resources

Area	R&I Criteria	Acreage[a]
Desolation Canyon WSA	NA[b]	229,860
Jack Canyon WSA	NA[b]	7,735
Mexican Mountain WSA	NA[b]	59,930
San Rafael Reef WSA	NA[b]	63,007
Sid's Mountain WSA	NA[b]	78,718
Devil's Canyon WSA	NA[b]	9,111
Crack Canyon WSA	NA[b]	26,640
Link Flats ISA	NA[b]	855
I-70 Scenic ACEC	Scenic resources	45,463
San Rafael Canyon ACEC	Scenic resources	54,102
Nine Mile Canyon	Cultural resources	22,335
San Rafael Reef ACEC[c]	Scenic resources and relict vegetation	84,018
Sid's Mountain ACEC	Scenic resources	61,380
Temple Mountain ACEC	Historic resources	2,444
Copper Globe ACEC	Historic resources	128

[a] Acreage estimates represent the entire unit (not just the portion overlying the tar sands resources) and were derived from GIS data compiled to support the PEIS analysis.

[b] NA = not applicable.

[c] Sid's Mountain was dropped as an ACEC in the 2008 RMP.

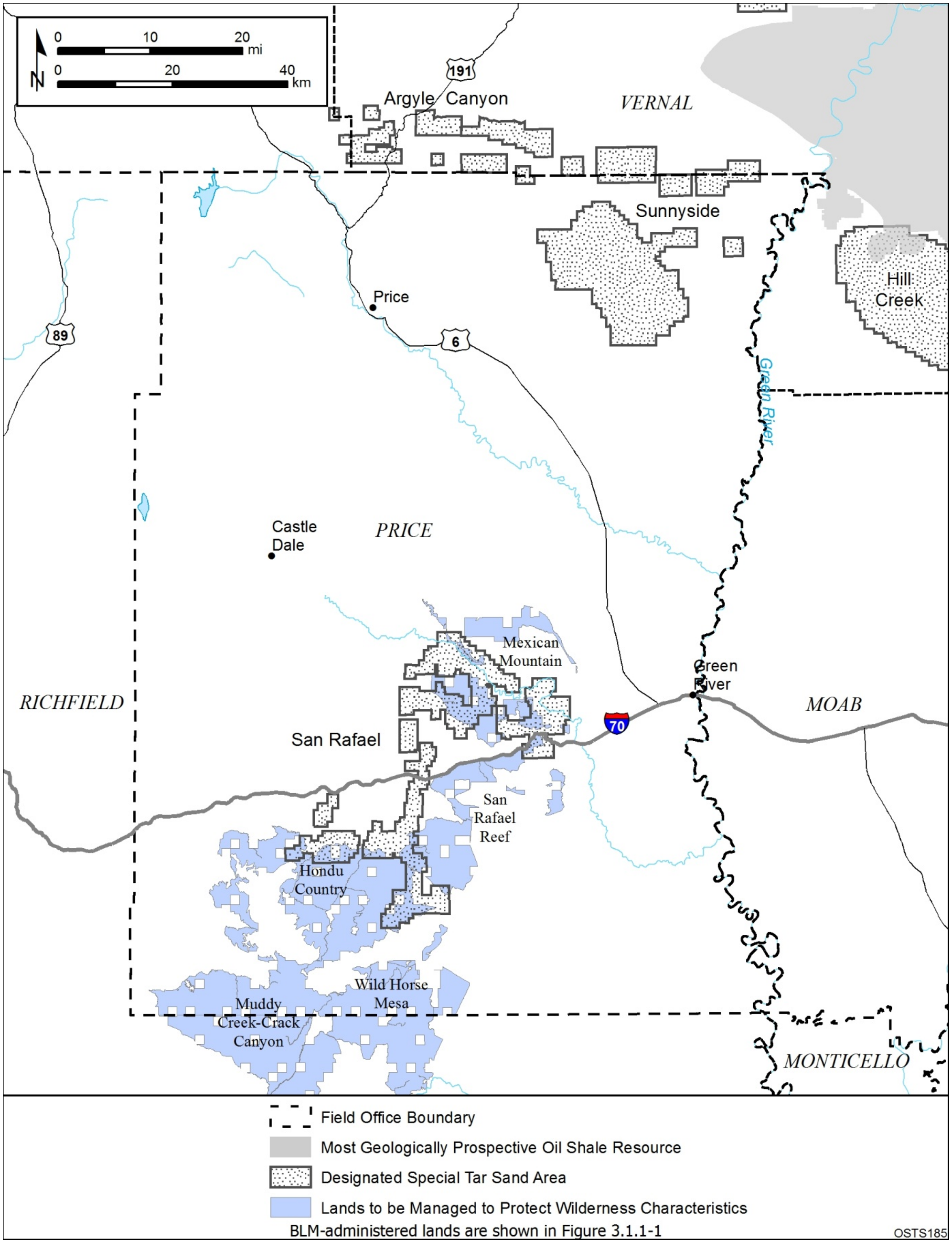

FIGURE 3.1.1-7 Areas with Wilderness Characteristics in the Price Field Office That the BLM Will Manage To Protect Those Characteristics That Overlap with Oil Shale and/or Tar Sands Deposits

TABLE 3.1.1-5 Non-WSA Lands Recognized as Having Wilderness Characteristics Designated for Long-Term Management in the Price Field Office That Overlap with Oil Shale and Tar Sands Deposits[a,b]

Name of Area with Wilderness Characteristics	Total Size of Area with Wilderness Characteristics to Be Managed (acres)	Amount of Overlap (acres)
Overlapping San Rafael STSA		
Hondu Country	20,121	4,206
Mexican Mountain	4,200	22,434
Muddy Creek–Crack Canyon	52,700	10,891
San Rafael Reef	3,300	6,017

a Key characteristics of wilderness that may be considered in land use planning include an area's appearance of naturalness and the existence of outstanding opportunities for solitude or primitive and unconfined types of recreation.

b Acreage estimates were derived from GIS data compiled to support the PEIS analyses.

3.1.1.7 Richfield Field Office, Utah

The Richfield Field Office RMP was completed in October 2008 and covers public lands within the Richfield Field Office boundary. This RMP replaces a 1982 MFP that had been amended multiple times. The field office region includes the Tar Sand Triangle STSA, portions of which extend into the Glen Canyon NRA and Canyonlands National Park and the Circle Cliffs STSA. The western portion of the Circle Cliffs STSA is located in the GSENM (see Section 3.1.1.4) and the eastern portion, while it is located within the Richfield Field Office boundary, is inside of Capitol Reef National Park. There are no oil shale resources located under lands managed by this field office. The 2008 OSTS PEIS and ROD made land use plan decisions regarding areas available for application for tar sands leasing within the field office for lands under BLM administration.

The Tar Sand Triangle STSA was historically available for tar sands or oil and gas development only through CHLs, subject to appropriate stipulations. While there are no existing CHLs in the STSA, there are seven pending conversion leases, totaling 41,254.16 acres. Four of these pending conversion leases, totaling 20,442.20 acres, fall within the Glen Canyon NRA. The BLM is engaged in an adjudication process to determine the status of these pending conversion leases and whether or not to convert them to CHLs. Under decisions made in the 2008 OSTS PEIS and ROD, BLM-administered land in the STSA is open for consideration for tar sands leasing pursuant to the regulations promulgated as required by the Energy Policy Act of 2005. (See 43 CFR subpart 3141.)

According to the *Mineral Potential Report* prepared for the Richfield Field Office (BLM 2005a), a wide variety of other energy and mineral resources are located on lands managed by the field office. However, the only other resources that are located in the immediate vicinity of the two STSAs with moderate or higher occurrence potential are oil and gas, coal, coalbed natural gas, gypsum and salt, uranium-vanadium, gold, other metals, clay, and stone.

Numerous oil and gas wells have been drilled within and in the vicinity of the Tar Sand Triangle STSA. All but two of these wells, however, have been plugged and abandoned, and there is no active production near either the Tar Sand Triangle or Circle Cliffs STSA (BLM 2005a). These areas are located within geologic provinces that have active production in areas outside the Richfield Field Office region (BLM 2005b); thus, production of oil or gas in the future is possible. Both the Tar Sand Triangle and Circle Cliffs STSA are located in portions of the planning area considered to have a high potential for the occurrence of oil in the tar sands deposits (BLM 2005a).

The Henry Mountains coal field is located to the east of the Circle Cliffs STSA. There are no coal resources in the vicinity of the Tar Sand Triangle STSA.

The Richfield Field Office administers grazing allotments that cover a significant portion of the planning area, but some of the grazing allotments in the vicinity of the Tar Sand Triangle STSA currently are not being grazed, and a portion of the STSA does not have grazing allotments associated with it. There are no specific recreation sites or SRMAs in the vicinity of the Tar Sand Triangle STSA. The Canyonlands Wild Burro HMA overlaps some of the tar sands resources (see Section 3.1.3 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be located on lands with tar sands resources.

Several WSAs are located in the general vicinity of the Tar Sand Triangle STSA (Figure 3.1.1-8). The Fiddler Butte and French Spring–Happy Canyon WSAs overlap with portions of the Tar Sand Triangle STSA. According to available maps, a very small portion of the Horseshoe Canyon and Dirty Devil WSAs also may overlap with this STSA. The Mount Pennell WSA is situated immediately to the east of the Circle Cliffs STSA, abutting in some places Capitol Reef National Park. One designated SRMA, Dirty Devil/Robber's Roost overlaps the Tar Sands Triangle STSA.

There are no designated ACECs near either of the two STSAs in the field office region (BLM 2005d).

A tract of land overlying the Tar Sand Triangle STSA has been recognized as having wilderness characteristics. About 24,255 acres of the Dirty Devil–French Spring non-WSA area, which possesses wilderness characteristics, overlaps a portion of the Tar Sands Triangle STSA, but in the ROD for the Richfield RMP the decision was made to not manage this area to protect wilderness characteristics.

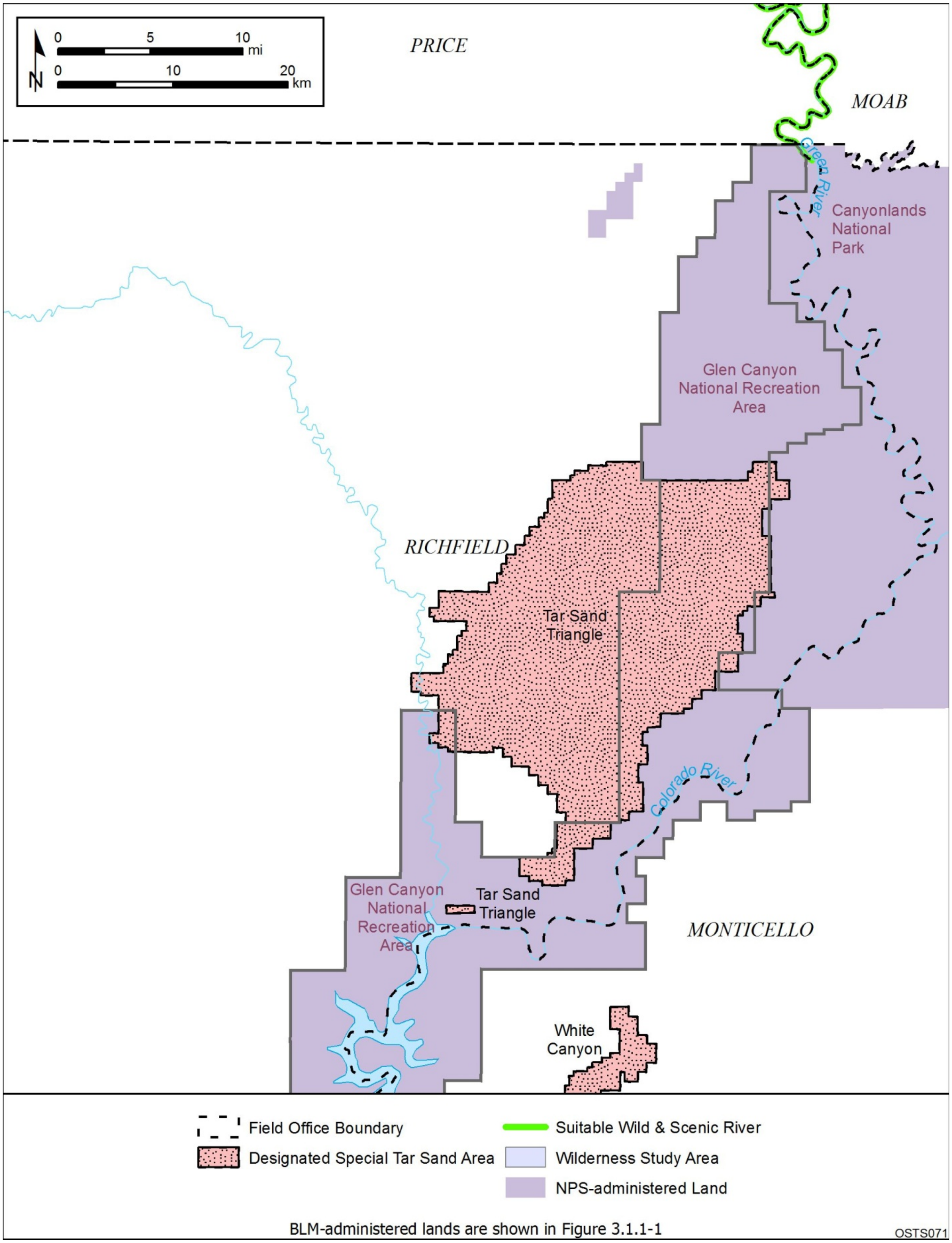

FIGURE 3.1.1-8 WSAs in the Richfield Field Office That Overlie the Tar Sand Triangle STSA

3.1.1.8 Vernal Field Office, Utah

Resources present in the Vernal Field Office are managed in accordance with the *Vernal Field Office Record of Decision and Approved RMP* (BLM 2008i). The Vernal RMP supersedes two previous plans: the *Diamond Mountain RMP* (BLM 1994a) and the *Book Cliffs RMP* (BLM 1985a). The 2008 OSTS PEIS and ROD made land use plan decisions regarding areas available for application for tar sands leasing within the field office for lands under BLM administration. The BLM administers almost 1.7 million acres of land within this planning area (Figure 3.1.1-9). Tar sands resources are located within the Hill Creek, P.R. Spring, Raven Ridge, Asphalt Ridge, Pariette, Sunnyside, and Argyle Canyon STSAs within the field office boundary.[2] The field office is located within the Uinta Basin and also contains oil shale resources.

Most of the Uintah and Ouray Indian Reservation is within the area managed by the Vernal Field Office. Lands within the reservation on which the subsurface mineral estate is owned by the Northern Ute Tribe were opened for leasing under the 2008 OSTS PEIS and ROD.

The subsurface mineral estate underlying about 188,500 acres within the Hill Creek Extension of the Uintah and Ouray Reservation is owned by the federal government, and leasing of these lands for oil shale and/or tar sands development was evaluated in the 2008 PEIS (Figure 3.1.1-10). Of these split estate lands, approximately 57,705 acres overlie the oil shale resources within the Uinta Basin, and approximately 35,472 acres overlie the Hill Creek STSA.

Although there currently is no tar sands development underway on BLM-administered lands, there are four permitted tar sands surface mining operations within the Vernal Field Office planning area, all in Uintah County (BLM 2006c). Prior to the issuance of the ROD for the 2008 OSTS PEIS, tar sands resources within the STSAs were available for tar sands or oil and gas development only through CHLs, subject to appropriate stipulations. Six CHLs are located within the Vernal Field Office region; 1,066.41 acres are held under four leases in the Pariette STSA, and 6,080.30 acres are held under two leases in the P.R. Spring STSA. In addition, there are eight pending conversion leases in the P.R. Spring STSA, totaling 27,668.04 acres. The BLM is engaged in an adjudication process to determine the status of these pending conversion leases and whether or not to convert them to CHLs. Under decisions made in the 2008 OSTS PEIS and ROD, BLM-administered land in the STSA is open for consideration for tar sands leasing pursuant to the regulations promulgated as required by the Energy Policy Act of 2005. (See 43 CFR subpart 3141.)

According to the *Mineral Potential Report for the Vernal Planning Area* (BLM 2002b), the other energy and mineral resources located within the field office region include oil and gas,

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2 A portion of the P.R. Spring STSA extends south from the Vernal Field Office boundary into the Moab Field Office boundary; however, this area is administered by the Vernal Field Office under a MOU with the Moab Field Office. Under this agreement, the Vernal Field Office administers all resources and programs, including land use planning, for the entire P.R. Spring STSA.

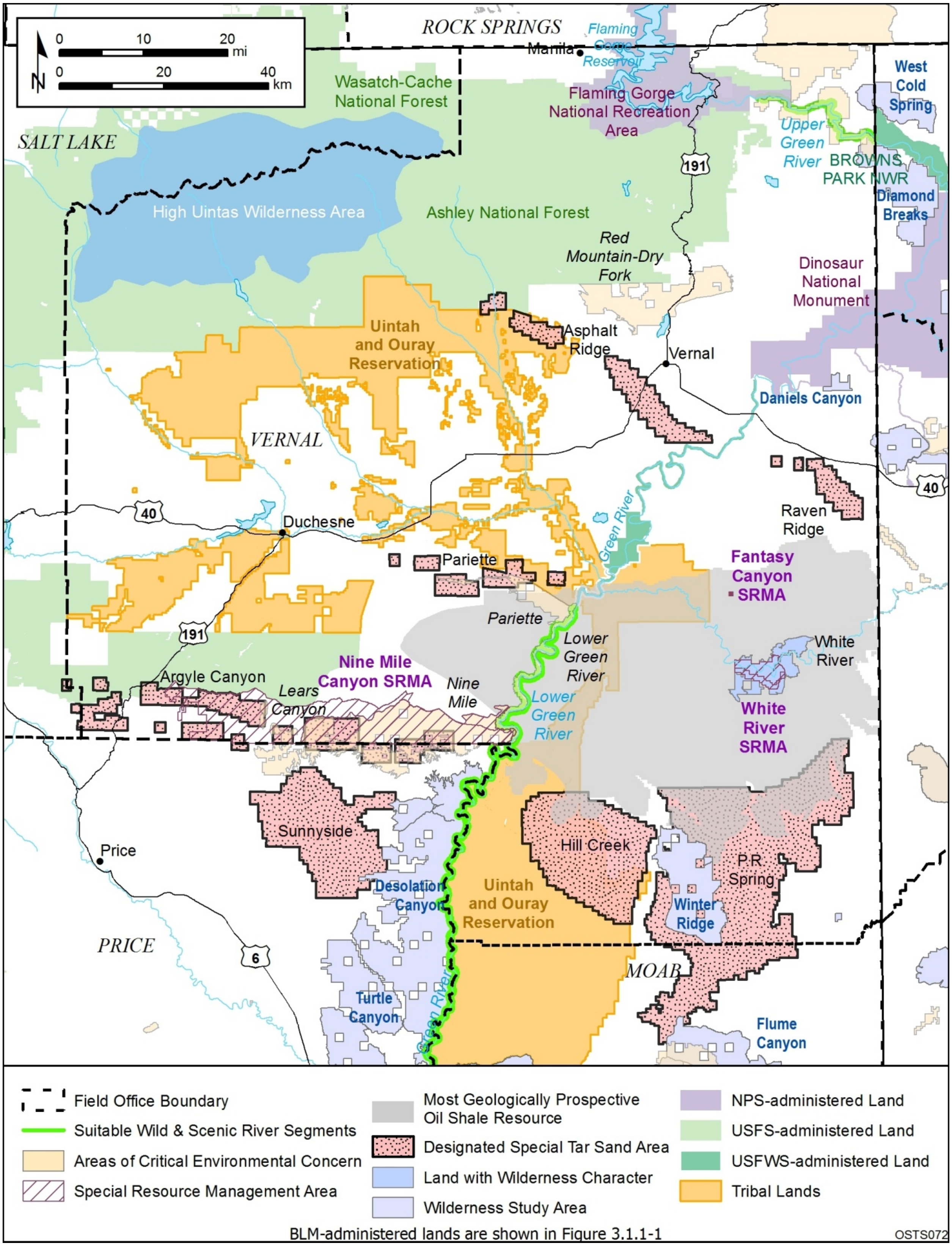

FIGURE 3.1.1-9 Vernal Field Office RMP Planning Area

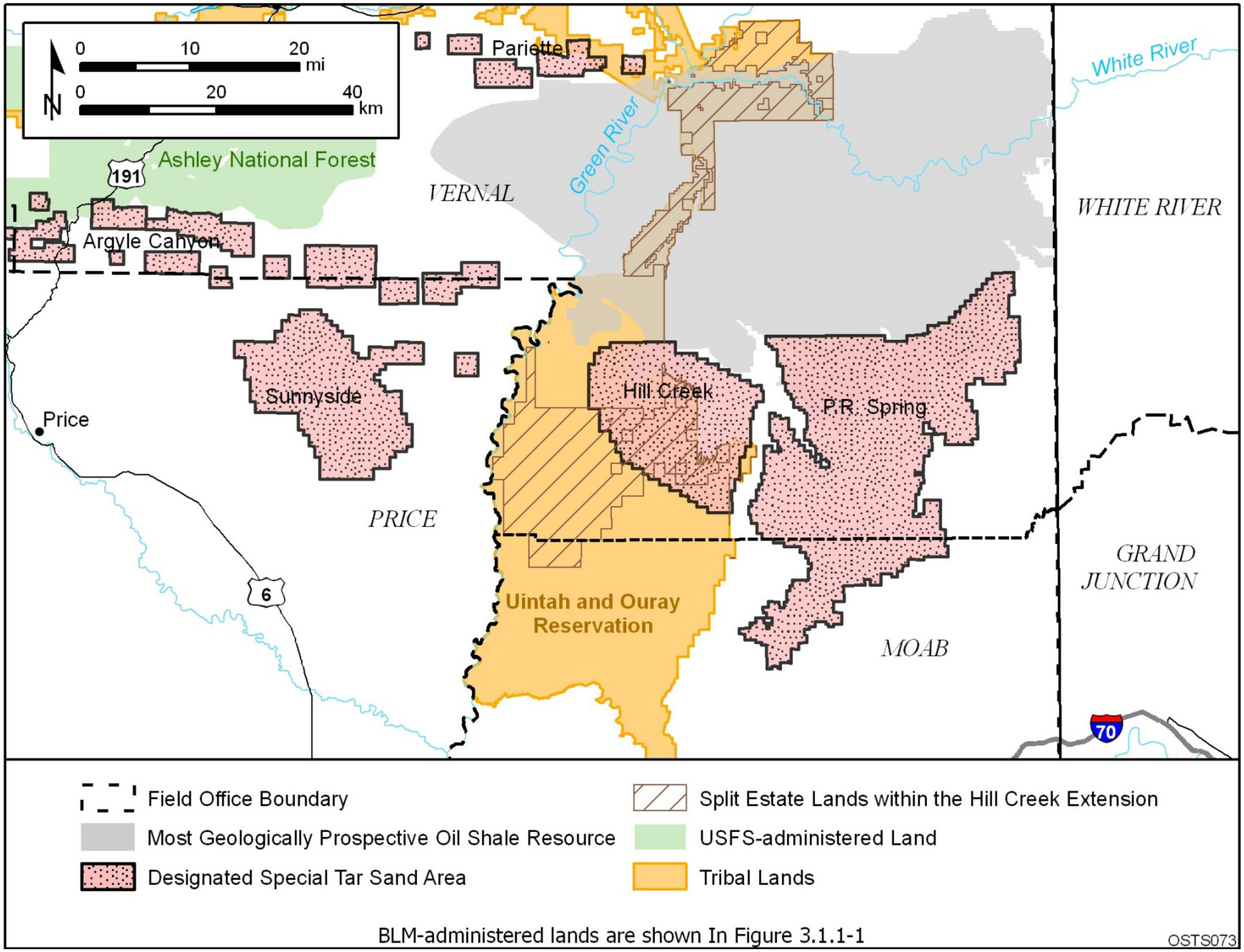

FIGURE 3.1.1-10 Split Estate Lands within the Hill Creek Extension of the Uintah and Ouray Reservation

coalbed natural gas, coal, gilsonite,[3] phosphate, uranium, gold, gypsum, sand and gravel, clay, and stone. Some of these resources are located in close proximity to the STSAs and oil shale resources. Unless otherwise noted, the following information about energy and mineral resources is from BLM (2002b).

About 9,036 active oil and gas wells are located within the Vernal Field Office planning area, and more than 1.8 million acres of land are available for leasing (for both conventional oil and gas and coalbed natural gas development), including about 188,500 acres of split estate lands within the Hill Creek Extension of the Uintah and Ouray Indian Reservation (BLM 2005e). Conventional oil and gas production occurs and is projected to continue in the future within five development areas, four of which include either tar sands or oil shale resources or both. Specifically, the Tabiona-Ashley Valley development area overlaps with the Asphalt Ridge and Raven Ridge STSAs. The Monument Butte-Redwash development area overlaps with the Raven Ridge and Pariette STSAs, as well as the oil shale resources within the Uinta Basin. In addition, the East Tavaputs Plateau development area overlaps with the Hill Creek and P.R. Spring STSAs as well as some of the oil shale resources. Existing oil and gas development is relatively limited in the Tabiona-Ashley Valley development area and is expected to remain low over the next 15 years. Conversely, development is extensive in the remaining three development areas and is expected to be relatively high in the next 15 years, especially in the Monument Butte-Redwash area, where 1,700 oil wells and 3,100 gas wells are projected. Although currently there is no coalbed natural gas production in the field office region, the potential exists within a small portion of the West Tavaputs Plateau area within the Uinta Basin–Book Cliffs Play near the Argyle Canyon STSA. Coalbed natural gas potential also exists within the East Tavaputs Plateau development area within the Uinta Basin Sego Play where the P.R. Spring STSA is located.

Coal mining has not occurred on public lands within the Vernal Field Office boundary because of lack of demand and poor quality of the deposits. Deposits in the Vernal coal field are co-located with the Asphalt Ridge and Raven Ridge STSAs, but development is considered unlikely in the next 15 years.

Gilsonite occurs in the Vernal Field Office planning area as vein-type deposits throughout much of the oil shale area being evaluated in the PEIS, as well as in the Pariette and P.R. Spring STSAs. Authorized leases and pending permit applications exist within the oil shale boundary. Gilsonite production is expected to continue over the next 15 years, as demand from the oil and gas industry for this drilling mud additive is expected to continue. Limited phosphate deposits are located within the Vernal Field Office boundary; they overlap with the western portion of the Asphalt Ridge STSA. Currently, there is no phosphate production on federal lease areas although the potential exists. Sand and gravel and stone mining occur throughout the Vernal Field Office planning area and are expected to continue. Mining claims for locatable minerals, including gold, uranium, and gypsum, are limited because of the low quality and quantity of these deposits. In addition, lands covered by the oil shale withdrawal are not open to mining claims.

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[3] Gilsonite is a black, homogeneous, solid hydrocarbon that is mined and used in the production of varnishes, lacquers, paints, some plastics, ink, and drilling muds.

Within the Vernal Field Office, designated livestock grazing allotments encompass more than 1.69 million acres of BLM-administered land. Approximately 545,000 additional acres of other lands (e.g., private, state, tribal) are included within these allotments. These allotments cover the majority of the planning area and are categorized on the basis of their resource production potential and resource use conflicts. Several SRMAs have been established within the planning area, some of which are co-located with the tar sands and oil shale resources, including the White River, Fantasy Canyon, and Nine Mile Canyon SRMAs. The Hill Creek Wild Horse HMA overlaps with some of the oil shale and tar sands resources (see Section 3.1.3 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the tar sands or oil shale resources.

There are two[4] WSAs and four ACECs that overlap with tar sands and/or oil shale resources that are shown in Figure 3.1.1-9 and listed in Table 3.1.1-6. In addition, two portions of the Green River have been determined to be suitable for designation as a WSR (see Appendix C of BLM 2005e). Those suitable segments that overlie or are near oil shale and/or tar sands deposits are shown in Figure 3.1.1-9 and include portions of the Upper and Lower Green River.

There are six non-WSA areas that overlie portions of the most geologically prospective oil shale area and three STSAs that have been recognized by the BLM as having wilderness characteristics. In the Vernal ROD, a decision was made to manage a portion of one of these areas, the White River area, shown in Figure 3.1.1-9, to protect wilderness characteristics. Within the total Vernal Field Office area, BLM has made decisions to manage 106,178 acres in 15 non-WSA areas to protect wilderness characteristics that are present.

Other lands with special designations are located within the boundaries of the Vernal Field Office (Figure 3.1.1-9). A portion of Dinosaur National Monument, a unit of the National Park System, is within the Vernal Field Office boundary; however, it does not overlie any of the oil shale or tar sands resources being evaluated in this PEIS. At its closest point, the Monument is just under 7 mi from the Raven Ridge STSA, 8.5 mi from the Asphalt Ridge STSA, and 17 mi from the oil shale resources being evaluated within the Uinta Basin. The Ashley National Forest and Wasatch-Cache National Forest both fall within the Vernal Field Office boundary. Lands within the Ashley National Forest overlie the Asphalt Ridge, Argyle Canyon, and Sunnyside STSAs. In addition, lands within the Flaming Gorge NRA, which is administered by the Ashley National Forest, overlie oil shale resources identified in the Green River Basin in Wyoming. The BLM does not make planning decisions for these National Forest lands. The High Uintas Wilderness Area, which is located within both the Ashley and Wasatch-Cache National Forests, does not overlie the oil shale or tar sands resources being evaluated in this PEIS. This Wilderness Area is more than 13 mi from the Asphalt Ridge STSA, the closest STSA, and more than 13.5 mi from the nearest oil shale resources being evaluated within the Green River Basin in Wyoming.

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4 Flume Canyon WSA is in the Moab Field Office but overlaps a portion of the P.R. Springs STSA that is managed by the Vernal Field Office.

TABLE 3.1.1-6 Vernal Field Office WSAs and ACECs That Overlap with Oil Shale and Tar Sands Resources

Area	R&I Criteria	Acreage[a]
Winter Ridge WSA	NA[b]	43,339
Flume Canyon WSA[c]	NA	1,466
Pariette Wetlands ACEC	Wetlands resources and special status bird habitat and plant communities	10,635
Lears Canyon ACEC	Relict plant communities	1,378
Lower Green River ACEC	Riparian habitat and scenic values	9,430
Nine Mile Canyon ACEC	Cultural and scenic resources and special status plant communities	48,151

[a] Acreage estimates represent the entire unit (not just the portion overlying the oil shale and/or tar sands resources) and were derived from GIS data compiled to support the PEIS analyses.

[b] NA = not applicable.

[c] Actually located in the Moab Field Office; Flume Canyon only overlaps tar sands resources.

3.1.1.9 Kemmerer Field Office, Wyoming

The Kemmerer Field Office completed the Kemmerer RMP in 2010. The BLM administers 1.4 million acres of surface lands and 1.6 million acres of federal mineral estate within the planning area encompassed by this RMP (Figure 3.1.1-11). The oil shale resources are located within the Green River Basin; no known tar sands resources are located within the boundaries of this field office. The 2008 OSTS PEIS and ROD made land use plan decisions regarding areas available for application for oil shale leasing within the field office for lands under BLM administration.

According to the *Kemmerer Field Office Planning Area Mineral Assessment Report* (BLM 2004b) that was prepared for the recent RMP, the other energy and mineral resources of note found within the field office include oil and gas, coalbed natural gas, coal, trona,[5] uranium, bentonite, sand, gravel, and decorative stone. Some of these resources are located in close proximity to the oil shale resources. Unless otherwise noted, the following information about energy and mineral resources is from the BLM (2004b).

5 Trona is a hydrous sodium carbonate mineral that is refined into soda ash, sodium bicarbonate, sodium sulfite, sodium tripolyphosphate, and chemical caustic soda.

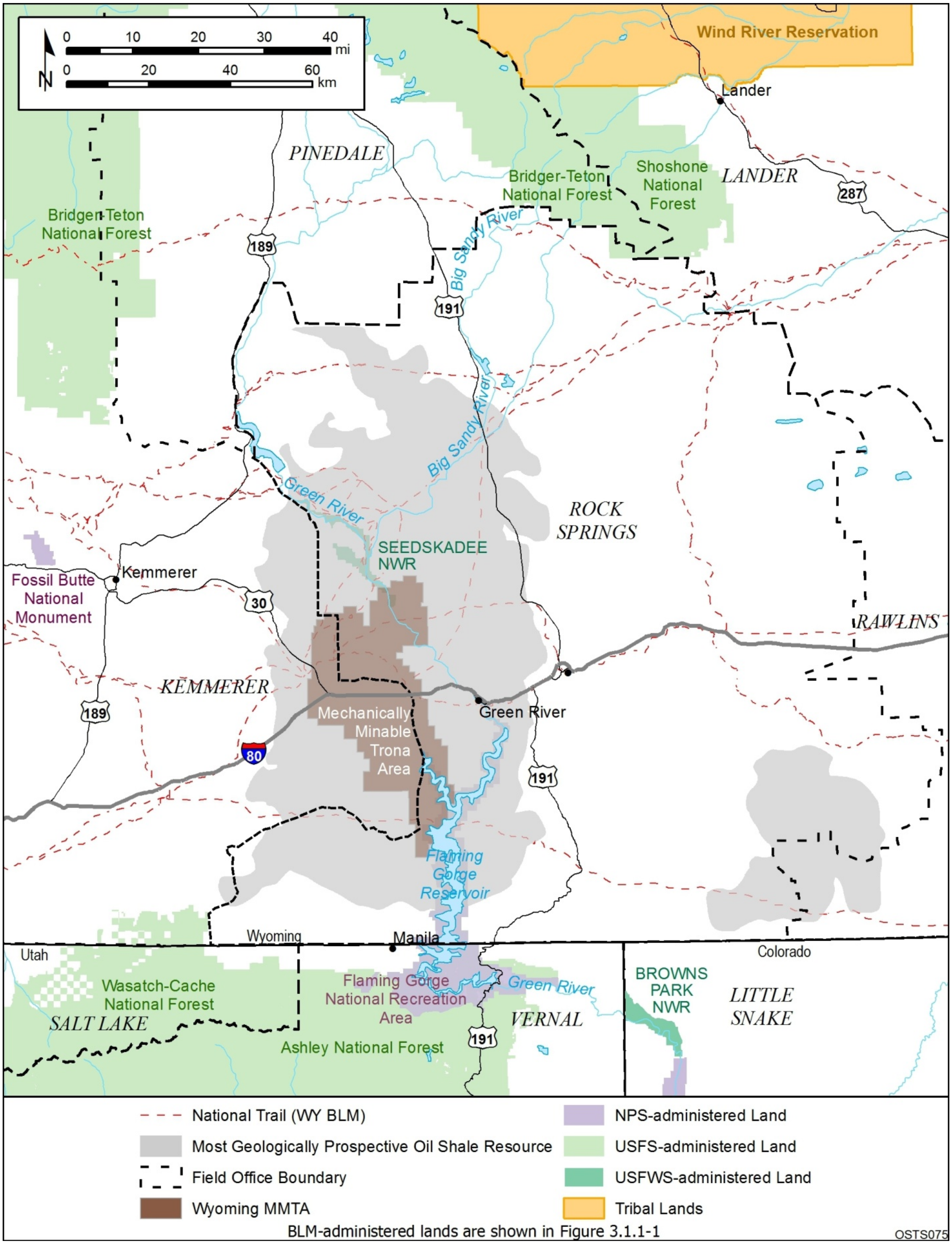

FIGURE 3.1.1-11 BLM Field Offices in Wyoming Where Oil Shale Resources Are Located

More than 1 million acres of land are currently leased for oil and gas development within the jurisdiction of this field office, including most of the federal subsurface mineral estate that coincides with the oil shale resource. Gas production in the Green River Basin is associated with gas fields located in and adjacent to the La Barge Platform–Moxa Arch trend. Coalbed natural gas wells have been drilled in the Kemmerer Field Office and, while production is currently low, more development is expected in the future.

Coal reserves in the Kemmerer Field Office area occur in two major regional coal fields: the Hams Fork Coal Field and the western portion of the Green River Coal Field. Coal production is currently occurring only in the Hams Fork Coal Field, which does not coincide with the oil shale resources located in the Green River Basin. There are no existing coal leases in the Green River Coal Field, which overlaps with the oil shale resources.

The world's largest known trona deposits exist within an area defined as a Known Sodium Leasing Area (KSLA), which extends into the eastern portion of the Kemmerer Field Office region. Trona leases have been issued within this area, and production occurs from a number of underground mines. The BLM has designated a portion of the KSLA as the Mechanically Mineable Trona Area (MMTA) (Figure 3.1.1-11) and determined that this area will be excluded from oil shale leasing until technology or other factors exist to allow development of the oil shale resource without jeopardizing the safe operation of underground trona mines. The KSLA covers all of the MMTA and most of the oil shale resources west and south of the MMTA.

The Kemmerer Field Office administers grazing on allotments that cover a significant portion of the southern half of the planning area, including most of the area where oil shale resources are located. Recreational use of BLM-administered lands is dispersed throughout the planning area. The BLM has designated some areas to be managed specifically to protect their recreation potential, but except for the areas adjacent to historic trails, most of these areas do not coincide with the oil shale resources. ROW authorizations exist within the planning area and may be located in areas with oil shale resources.

A small portion of one WSA that is shared with the Rock Springs Field Office, as well as several locations where there are populations of sensitive plant species that may be designated as ACECs on a case-by-case basis, are within the Kemmerer planning area and overlap with the oil shale resources (Figure 3.1.1-12). There is no non-WSA land identified as possessing wilderness characteristics overlapping oil shale resources within the field office boundary. Several historic trails cross the area where oil shale resources are located (see Section 3.9.4). Lands within the Wasatch-Cache National Forest at the southern edge of the planning area are adjacent to but do not overlap with the oil shale resources (Figure 3.1.1-11). Specially designated lands and trails are shown in Figure 3.1.1-12.

3.1.1.10 Rawlins Field Office, Wyoming

The Rawlins RMP was completed in 2008 (BLM 2008c). The BLM administers 3.5 million acres of surface lands and 4.5 million acres of federal mineral estate within the

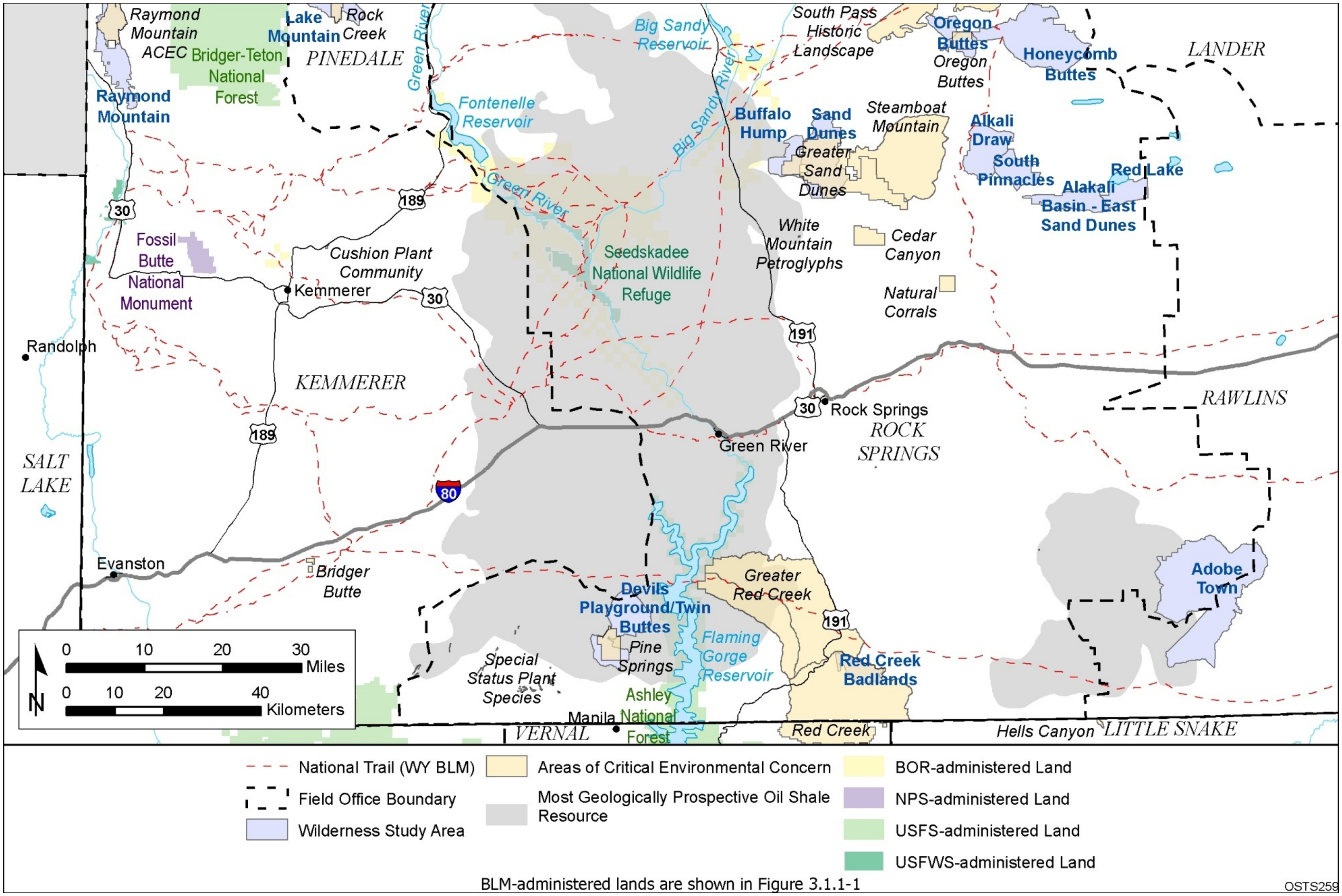

FIGURE 3.1.1-12 Specially Designated Areas in the Kemmerer Field Office

planning area encompassed by this RMP (Figure 3.1.1-11). The oil shale resources are located within the Washakie Basin in the very southwestern portion of the Rawlins Field Office area. No known tar sands resources are located within the boundaries of this field office. The 2008 OSTS PEIS and ROD made land use plan decisions regarding areas available for application for oil shale leasing within the field office for lands under BLM administration.

Other energy and mineral resources of note located within the field office include oil and gas, coalbed natural gas, coal, and uranium. Most of these resources are not located in close proximity to the oil shale resources. Unless otherwise noted, the following information about energy and mineral resources is from the Draft Rawlins RMP EIS (BLM 2004e). The majority of the oil and gas fields are located in the western portion of the planning area but to the east or north of the oil shale resources. Oil and gas development is increasing significantly in the region; the greatest level of development in the Rawlins Field Office is concentrated in the Great Divide Basin, which is largely to the north of the oil shale resources. While there has been little coalbed natural gas production in this area, interest is increasing. There are six coal fields in the Rawlins Field Office, but all are located to the east of the oil shale resources.

The Rawlins Field Office administers grazing on allotments that cover a significant portion of the western half of the planning area, including most of the area where oil shale resources are located. Recreation is one of the major uses of BLM-administered lands within this planning area. Recreation sites have been established in areas of heavy recreational use; larger areas of dispersed but heavy recreational use also have been identified and designated as SRMAs. None of the designated recreation sites or SRMAs is located in an area overlying the oil shale resources. The Adobe Town Wild Horse HMA overlaps with some of the oil shale resources (see Section 3.1.3 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the oil shale resources.

None of the ACECs designated in the Rawlins planning area overlap with the oil shale resources. One historic trail, the southern route of the Cherokee Trail, crosses the area where oil shale resources are located (Figure 3.1.1-13; see Section 3.9.4).

The Adobe Town WSA straddles the Rawlins and Rock Springs Field Office boundary and includes about 82,350 acres of BLM-administered land. The BLM recommended that about 11,000 acres of the area be designated as wilderness in its 1992 Report to Congress. About 33,389 acres of the WSA overlap with oil shale resources in the Washakie Basin (Figure 3.1.1-13), with 7,885 acres being located within the Rawlins Field Office. The WSA also sits within a larger area that was designated by the Wyoming Environmental Quality Council (WEQC) in 2008 as the Adobe Town "Very Rare or Uncommon Area." The Very Rare or Uncommon Area includes 180,910 total acres, of which 167,517 acres are public land. Its boundary overlaps 50,025 acres of the oil shale basin, with 17,879 acres being located within the Rawlins Field Office. The WEQC designation applies only to state mining permits issued by Wyoming Department of Environmental Quality (WDEQ) and would protect the area from state-authorized non-surface coal mining and surface mining for oil shale, uranium, and gravel pit mining. The designation does not limit oil and gas leasing, exploration, production, or related construction.

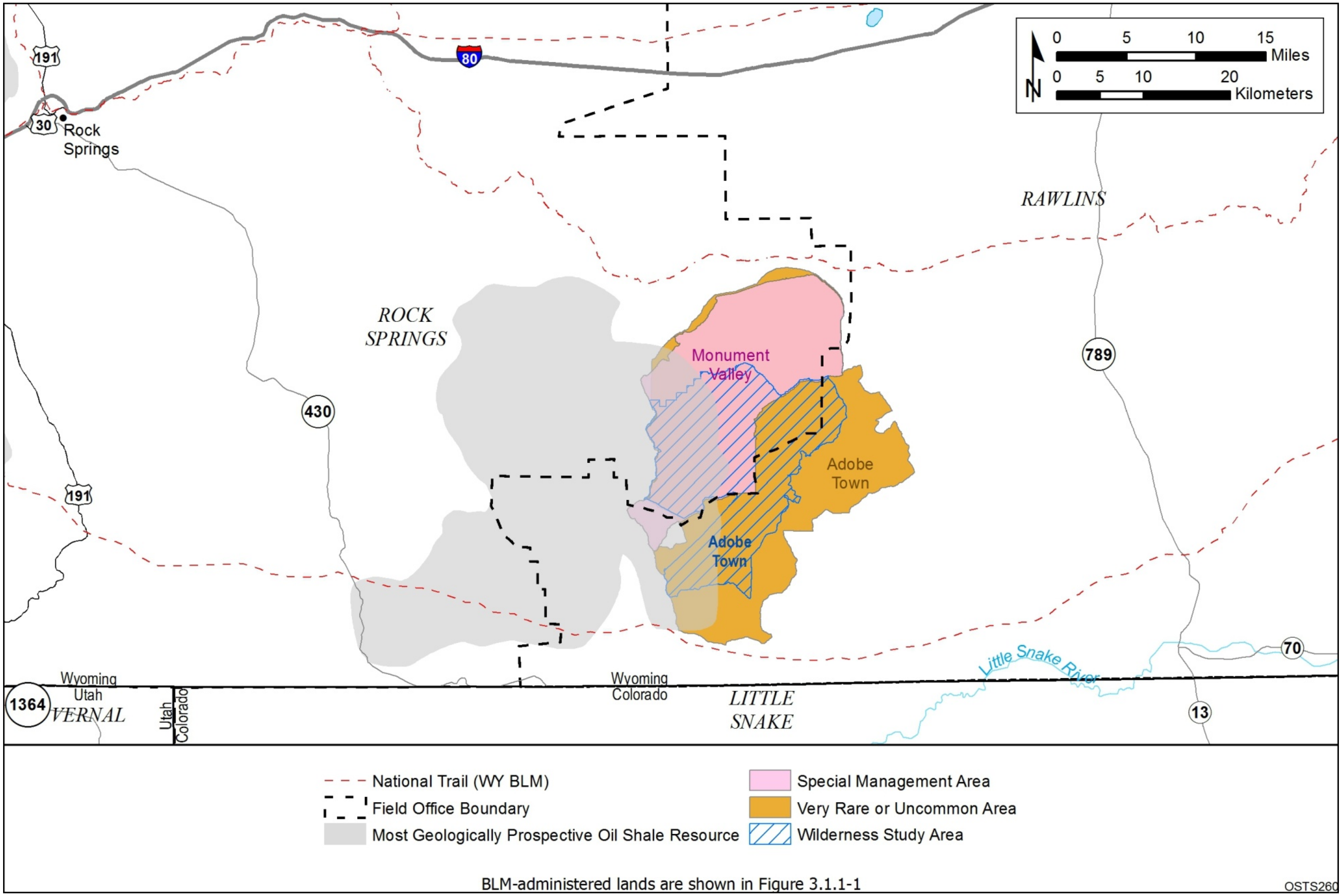

FIGURE 3.1.1-13 Specially Designated Areas Overlapping the Most Geologically Prospective Area

Portions of the Adobe Town/Kinney Rim area were determined by the BLM to contain wilderness characteristics. These areas are located on the western and eastern borders of the WSA. All but one of these areas is within the WEQC-designated Adobe Town "Very Rare or Uncommon Area." Based on the presence of existing oil and gas leases within the areas with wilderness characteristics outside the WSA, it was determined in the Rawlins RMP that all of these areas would be managed as multiple-use lands and not for protection of wilderness characteristics. The Kinney Rim South unit west of the WSA was mistakenly identified in the Draft PEIS as an area with wilderness characteristics. The BLM had previously reviewed this area and had determined that wilderness characteristics were not present. The approved Rawlins RMP includes the designation of the lands within the Rawlins District located west and south of the Adobe Town WSA as the Adobe Town Dispersed Recreation Use Area (DRUA). All of the Adobe Town "Very Rare or Uncommon Area" outside of the WSA within the Rawlins Field Office is included within the DRUA.

3.1.1.11 Rock Springs Field Office, Wyoming

The Green River RMP was issued in 1997 (BLM 1997b), and several maintenance changes have been implemented over time. The Rock Springs Field Office is in the beginning stages of a plan revision process that will replace the current plan. The BLM administers about 3.6 million acres of public land surface and 3.5 million acres of federal mineral estate (Figures 3.1.1-11 and 3.1.1-14). Oil shale resources are located within both the Green River and Washakie Basins; no known tar sands resources are located within the boundaries of this field office. The 2008 OSTS PEIS and ROD made land use plan decisions regarding areas available for application for oil shale leasing within the field office for lands under BLM administration.

In 2006, the Green River RMP was amended by the *Jack Morrow Hills Coordinated Activity Plan* (JMHCAP) (BLM 2006b). Only a small portion of the Jack Morrow Hills area overlaps with oil shale resources in the Green River Basin being evaluated in this PEIS, and because of decisions made in formulation of alternatives for the PEIS, less than 20,000 acres on the very western edge of the JMHCAP area is available for oil shale leasing.

Other energy and mineral resources of note located within the field office include oil and gas, coalbed natural gas, coal, geothermal resources, and trona.

As discussed in Section 3.1.1.9, the world's largest known trona deposits exist within a designated KSLA that straddles the boundary between the Rock Springs and Kemmerer Field Offices. Trona leases have been issued within this area, and production occurs from a number of underground mines. The BLM has designated a portion of the KSLA as the MMTA (Figure 3.1.1-11) and determined that this area will be excluded from oil shale leasing until technology or other factors allow development of the oil shale resource without jeopardizing the safe operation of underground trona mines. The KSLA covers all of the MMTA and most of the oil shale resources west and south of the MMTA.

The Rock Springs Field Office administers grazing on allotments that cover almost the entire planning area, including most of the areas where oil shale resources are located. The

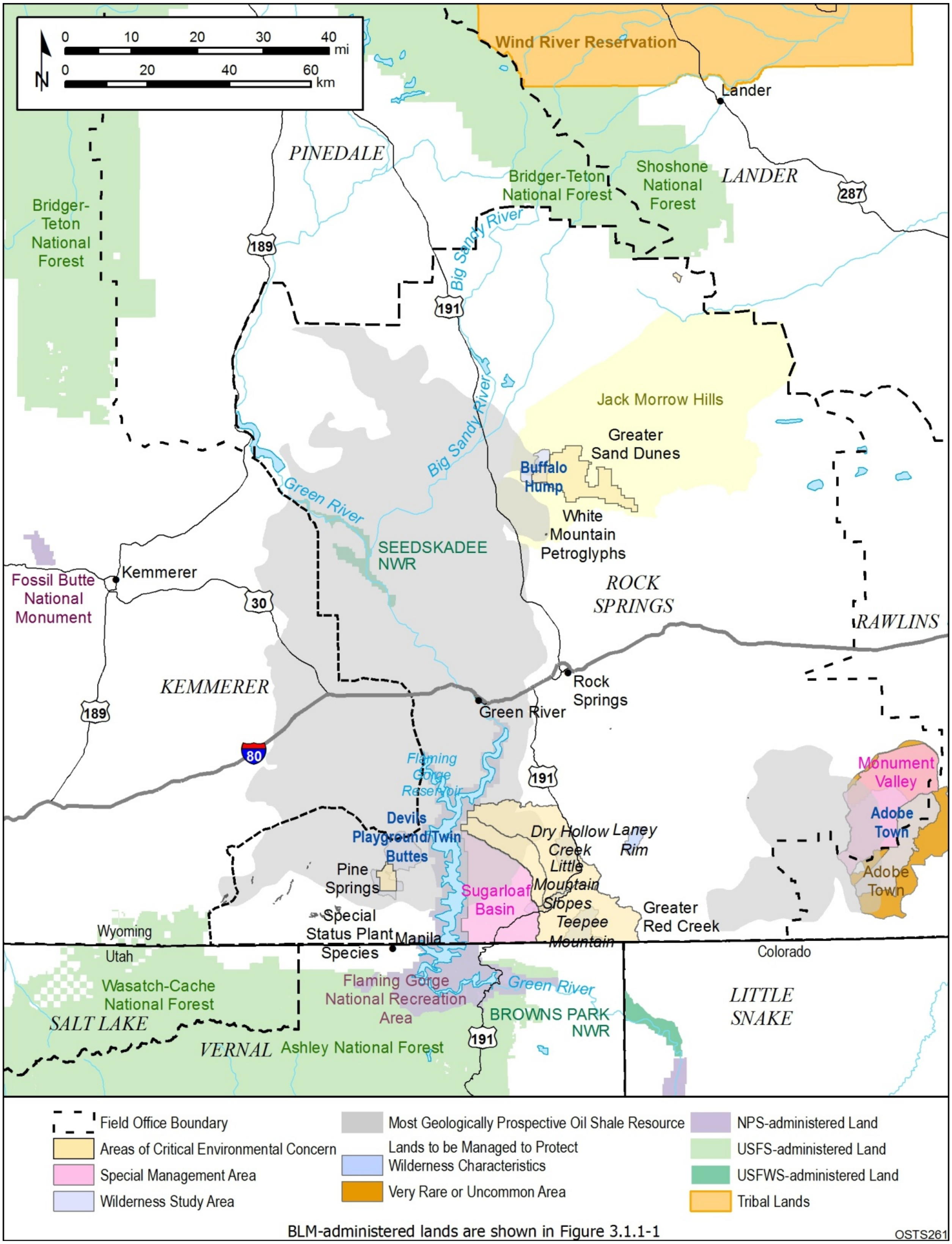

FIGURE 3.1.1-14 Specially Designated Areas in the Rock Springs Field Office

Adobe Town, Little Colorado, Salt Wells Creek, and White Mountain Wild Horse HMAs overlap with some of the oil shale resources (see Section 3.1.3 for more information on wild horses and burros). ROW authorizations exist within the planning area and may be co-located with the oil shale resources.

Portions of three WSAs and five ACECs overlap oil shale resources in the Green River and Washakie Basins within the Rock Springs Field Office boundary. With respect to any new potential ACECs, the Rock Springs Field Office has not yet completed its ACEC report. Any decisions regarding designation and management of ACECs will be made by the Rock Springs Field Office through their land use planning process. In addition, several historic trails cross the area (see Figure 3.1.1-11) where oil shale resources are located (see Section 3.9.4). Recreation sites have been established in areas that coincide with the oil shale resources in the Green River Basin, and three designated SMAs overlap or are adjacent to oil shale resources in the Rock Springs Field Office. The BLM has established stipulations restricting surface-disturbance activities within the two SMAs that overlap the oil shale resources being evaluated in this PEIS. Areas discussed in this paragraph are shown in Figure 3.1.1-14 and listed in Table 3.1.1-7.

In the southeastern part of the Rock Springs Field Office area, the Monument Valley SMA, the Adobe Town Very Rare and Uncommon Area, and the Adobe Town WSA overlap one another to varying degrees and overlap the most geologically prospective area as well (also see the discussion of the Adobe Town area in Section 3.1.1.10 above). The Monument Valley SMA almost completely overlaps the portion of the Adobe Town Very Rare or Uncommon Area designated by the Wyoming Environmental Council within the Rock Springs Field Office area. The SMA contains 98,308 acres, of which 32,572 acres within the the Rock Springs Field Office overlap oil shale resources in the Washakie Basin. There are 32,146 acres of the Very Rare and Uncommon Area within the Rock Springs Field Office that also overlap these resources (see Figure 3.1.1-11).

The Pine Mountain SMA is adjacent to the southwestern boundary of the Washakie Basin most geologically prospective area. The Kinney Rim North unit west of the Adobe Town WSA was mistakenly identified in the Draft PEIS as an area with wilderness characteristics. The BLM had previously reviewed this area and had determined that wilderness characteristics were not present.

The Flaming Gorge NRA, a unit within the Ashley National Forest, is located within the Rock Springs Field Office boundary and overlaps in part with the oil shale resources in the Green River Basin being evaluated in this PEIS; however, the BLM is not making land allocation decisions for Forest Service–administered areas in this PEIS. The High Uintas Wilderness Area, which is located within both the Ashley and Wasatch-Cache National Forests in northern Utah, is more than 13.5 mi at its closest point from the oil shale resources being evaluated within the Green River Basin in Wyoming (see Figure 3.1.1-11).

3.1.2 Recreational Land Use in the Three-State Study Area

Recreational use of BLM-administered lands within the three-state study area is varied and dispersed. Specific recreation sites and use areas have been designated by the BLM

TABLE 3.1.1-7 Rock Springs Field Office WSAs, SMAs, and ACECs That Overlap with Oil Shale Resources

Area	R&I Criteria	Acreage[a]
Devils Playground/Twin Buttes WSA	NA[b]	23,070
Buffalo Hump WSA	NA	9,480
Adobe Town WSA	NA	54,330
White Mountain Petroglyphs ACEC	Cultural values	20[c]
Greater Red Creek ACEC	Fragile soils, unique ecological features, watershed and cultural values, sensitive species	131,890[c]
Pine Springs ACEC	Cultural values	6,030[c]
Greater Sand Dunes ACEC	Outstanding geologic features, prehistoric and historic values, recreation values	38,650[c]
Special Status Plant Species ACEC	Natural processes, fragile plant species	900[c]
Adobe Town Very Rare or Uncommon Area	NA	32,146
Monument Valley SMA	NA	98,308
Sugarloaf Basin SMA	NA	92,962
Pine Mountain SMA	NA	64,200[c]
Jack Morrow Hills Area 3	NA	233,350

[a] Unless otherwise noted, acreage estimates represent the entire unit (not just the portion overlying the oil shale resources) and were derived from GIS data compiled to support the PEIS analyses.

[b] NA = not applicable.

[c] Acreage estimate was derived from the Green River RMP (BLM 1997b).

throughout the region. To facilitate and manage OHV use, existing land use plans within the study area identify areas that are designated as either closed, open, or limited to OHV use, and these designations overlap oil shale and tar sands resources.

Generally, the BLM provides recreational opportunities where they are compatible with other authorized land uses, while minimizing risks to public health and safety and maintaining the health and diversity of the land. The Recreation Opportunity Spectrum (ROS) is one of the means that the BLM uses to inventory, plan, and manage recreational use. Seven elements provide the basis for inventorying and delineating recreational settings: access, remoteness, naturalness, facility and site management, visitor management, social encounters, and visitor impacts. Based on these elements, the BLM (1981) utilizes six ROS classes to describe management goals:

1. *Primitive.* Large areas of about 5,000 acres (2,023 ha) or more located at least 3 mi (5 km) from the nearest point of motor vehicle access;

2. *Semiprimitive nonmotorized.* Areas of about 2,500 acres (1,012 ha) located at least 0.5 mi (0.8 km) from the nearest point of motor vehicle access;

3. *Semiprimitive motorized.* Areas of about 2,500 acres (1,012 ha) located within 0.5 mi (0.8 km) of primitive roads and two-track vehicle trails;

4. *Roaded natural.* Areas near improved and maintained roads;

5. *Rural.* Areas characterized by a substantially modified natural environment; and

6. *Urban.* Areas located near paved highways where the landscape is dominated by human modification.

The BLM also distinguishes recreational use on the basis of the level of use and management requirements. Areas designated as Special Recreation Management Areas (SRMAs) require recreation activity plans and a major investment in facilities or supervision of more intensive activities. Areas designated as Extensive Recreation Management Areas (ERMAs), however, offer mostly unstructured, dispersed, and low-intensity recreational opportunities that require a minimum amount of facilities and management. These designations are made through the land use planning process. Both SRMAs and ERMAs are found within the study area. In addition to SRMAs, many of the areas with special designations, such as ACECs, WSAs, SMAs, national historic trails, and lands with wilderness characteristics, support higher levels of recreation use than most BLM-administered areas.

Other federal and state agencies also manage a wide variety of recreational areas in the region, and recreational use is a significant part of the regional economy. Table 3.1.2-1 provides at least a partial listing of the many recreational areas and other areas that may provide recreation opportunities located within about a 50-mi radius of the oil shale and tar sands resources evaluated in this PEIS. This information was derived from various Internet sites and may not be all inclusive; it does not include recreation sites and areas, WSAs, or ACECs that are managed by the BLM and also occur in the area (many of these are discussed in Section 3.1.1). The intent of the table is to demonstrate the overall importance of recreational land use and the large variety of recreation areas in the region.

3.1.3 Wild Horses and Burros in the Three-State Study Area

The Wild Free-Roaming Horses and Burros Act passed by Congress in 1971 gave the BLM the responsibility to protect, manage, and control wild horses (*Equus caballus*) and burros (*E. asinus*) (BLM 2011a). The general management objectives for wild horses and burros are to (1) protect, maintain, and control viable, healthy herds with a diverse age structure, while retaining their free-roaming nature; (2) provide adequate habitat for wild horses through principles of multiple use and environmental protection; (3) maintain a thriving natural ecological balance with other resources; (4) provide opportunities for the public to view wild horses; and (5) protect them from unauthorized capture, branding, harassment, or death (BLM 1991a, 1996, 1997b, 2008b).

The BLM establishes HMAs for the maintenance of wild horse and burro herds in compliance with the Wild Free-Roaming Horses and Burros Act (BLM 2004b). Herd population management is important for balancing herd numbers with forage resources and with other uses of the public and adjacent private lands (BLM 2004d, 2008c). Wild horses and burros that are found outside of HMAs are considered excess and are subject to removal (BLM 2004b).

TABLE 3.1.2-1 Federal and State Recreation Areas within a 50-mi Radius of the Most Geologically Prospective Oil Shale Areas and STSAs

Recreation Area[a]	Managing Agency[b]
Colorado	
Black Ridge Canyons Wilderness Area	BLM
Brown's Park National Wildlife Refuge	USFWS
Canyon Pintado National Register Historic District	BLM
Colorado National Monument	NPS
Dinosaur Diamond National Scenic Byway	DOT
Dinosaur National Monument	NPS
Elkhead Reservoir	CSP
Flat Tops Wilderness Area	USFS
Grand Mesa National Forest	USFS
Grand Mesa Scenic and Historic Byway	DOT
Harvey Gap State Park	CSP
Highline Lake State Park	CSP
James M. Robb–Colorado River State Park	CSP
McInnis Canyons National Conservation Area	BLM
Maroon Bells Wilderness Area	USFS
Rabbit Valley Research Natural Area	BLM
Raggeds Wilderness Area	USFS
Routt National Forest	USFS
Horsethief Canyon State Wildlife Area	BOR
Rifle Falls State Park	CSP
Rifle Gap Reservoir and State Park	BOR and CSP
Sweitzer Lake State Park	CSP
Vega Reservoir and State Park	BOR and CSP
White River National Forest	USFS
Yampa River State Park	CSP
Utah	
Anasazi Indian State Park	USPR
Arches National Park	NPS
Ashley National Forest	USFS
Bryce Canyon National Park	NPS
Box-Death Hollow Wilderness Area	USFS
Canyonlands National Park	NPS
Capitol Reef National Park	NPS
Cleveland-Lloyd Dinosaur Quarry	BLM
Dark Canyon Wilderness Area	USFS
Dead Horse Point State Park	USPR
Dinosaur Diamond National Scenic Byway	DOT
Dinosaur National Monument	NPS
Dixie National Forest	USFS
Edge of the Cedars State Park	USPR
Escalante State Park	USPR
Fantasy Canyon	BLM
Fishlake National Forest	USFS
Flaming Gorge National Recreation Area	USFS

TABLE 3.1.2-1 (Cont.)

Recreation Area[a]	Managing Agency[b]
Utah (Cont.)	
Flaming Gorge–Uintas Scenic Byway	DOT
Glen Canyon National Recreation Area	NPS
Grand Staircase–Escalante National Monument	BLM
Green River State Park	USPR
Goblin Valley	USPR
High Uintas Wilderness Area	USFS
Huntington North Reservoir and Huntington State Park	BOR and USPR
Joes Valley Reservoir	BOR
Kodachrome Basin State Park	USPR
Manti-La Sal National Forest	USFS
Millsite State Park	USPR
Moon Lake Reservoir	BOR
Mt. Nebo Wilderness Area	USFS
Ouray National Wildlife Refuge	USFWS
Palisade State Park	USPR
Red Fleet Reservoir and State Park	BOR and USPR
Scofield Reservoir and State Park	BOR and USPR
Starvation Reservoir and State Park	BOR and USPR
Steinaker Reservoir and State Park	BOR and USPR
Uinta National Forest	USFS
Upper Stillwater Reservoir	BOR
Wasatch-Cache National Forest	USFS
Wyoming	
Bear River State Park	WSPCR
Bridger National Forest	USFS
Bridger Wilderness Area	USFS
Cokeville Meadows National Wildlife Refuge	USFWS
Fitzpatrick Wilderness Area	USFS
Flaming Gorge National Recreation Area	USFS
Fort Bridger State Park	WSPCR
Fossil Butte National Monument	NPS
Medicine Bow National Forest	USFS
Oregon, Mormon, Pioneer, California, and Pony Express Trails	BLM
Popo Agie Wilderness Area	USFS
Seedskadee National Wildlife Refuge	USFWS
Shoshone National Forest	USFS
Wasatch-Cache National Forest	USFS

[a] Includes areas that are within or partially within an approximately 50-mi radius.

[b] Abbreviations: BLM = Bureau of Land Management; BOR = Bureau of Reclamation; CSP = Colorado State Parks; DOT = U.S. Department of Transportation; NPS = National Park Service; USFS = U.S. Forest Service; USFWS = U.S. Fish and Wildlife Service; USPR = Utah State Parks and Recreation; WSPCR = Wyoming Department of State Parks and Cultural Resources.

Sources: Recreation.gov (2006); Colorado State Parks (2006a); Utah State Parks and Recreation (2006); Wyoming Division of State Parks and Historic Sites (2006).

Generally, their annual home range varies between 25 and 300 km^2 (NatureServe 2011). Because wild horse herds can increase in size by up to 25% annually, they can affect the condition of their range and increase competitive pressure among wild horses, livestock, and wildlife. Wild horse and burro herds are maintained through gathers. Gathered horses and burros are either placed for adoption through the Adopt-a-Horse Program or otherwise placed in long-term holding facilities. The BLM is currently researching the use of immunocontraceptives to slow the reproductive rate of wild horses (BLM 2008c).

Wild horses generally occur in common social groups of several females that are tended by a dominant male. Young males are expelled from the social group when they are 1 to 3 years old and form bachelor groups (NatureServe 2011). They feed on grass and grasslike plants and browse on shrubs in winter. They visit watering holes daily and may dig to water in dry river beds (NatureServe 2011).

Wild burro males control a small territory during the breeding season. When not with females, older males are generally solitary. Females tend to be either alone with their foal or in groups with other females and foals (NatureServe 2011). The home range for the wild burro can range from 4 to 97 km^2 (2 to 37 mi^2). They feed on grasses, sedges, forbs, and browse.

Table 3.1.3-1 lists the wild horse and burro HMAs within or near the areas where oil shale or tar sands may be developed. Horse and burro populations that occurred within the HMAs during FY 2011 are also provided. Figure 3.1.3-1 shows the distribution of the wild horse and burro HMAs within the oil shale and tar sands study area.

3.2 GEOLOGICAL RESOURCES AND SEISMIC SETTING

Extensive work has been conducted in the study area to describe the geologic setting (e.g., Cashion 1964; Culburtson and Pitman 1973; Dyni 2003; Blackett 1996). In addition, Chapter 2 and Appendices A and B provide general information regarding oil shale and tar sands resources and geology, respectively. A brief summary of the geologic setting for each major basin and STSA is presented in this section.

3.2.1 Piceance Basin

3.2.1.1 Physiography

The Piceance Basin is located mainly in the Colorado Plateau physiographic province (Figure 1.2-1). The Piceance Basin is simultaneously a structural, depositional, and drainage basin. The structural basin is downwarped and surrounded by uplifts resulting from the Laramide Orogeny. This tectonic activity created a depositional basin that filled with sediments from the surrounding uplands, mainly during the Tertiary period. The Piceance Basin is not referred to or described consistently in the published literature. Some publications describe the Piceance Basin as an area encompassing more than 7,000 mi^2 and consisting of a northern province and a

TABLE 3.1.3-1 Wild Horse Herd Management Areas within the Oil Shale and Tar Sands Study Area (FY 2011)

	Herd Management Area Size		Population[a]	
Herd Management Area Name (County)	BLM Acres	Other Acres	Horse	Burro
Colorado				
Piceance-East Douglas (Rio Blanco)	158,332	31,684	320 (135–235)	0 (0)
Utah				
Canyonlands (Wayne)	77,254	12,138	0 (0)	0 (100)
Muddy Creek (Emery)	252,086	31,388	72 (125)	0 (0)
Range Creek (Carbon)	43,235	11,788	149 (125)	0 (0)
Sinbad (Emery)	89,465	9,776	0 (0)	94 (70)
Wyoming				
Little Colorado (Sweetwater, Sublette, and Lincoln)	525,421	104,608	256 (100)	0 (0)
White Mountain (Sweetwater)	207,372	184,496	545 (300)	0 (0)
Salt Wells Creek (Sweetwater)	687,546	483,182	300 (365)	0 (0)
Adobe Town (Sweetwater)	444,244	34,631	738 (800)	0 (0)

[a] Numbers in parentheses are the appropriate management level (i.e., number of wild horses and burros that the HMA can support).

Source: BLM (2011a).

southern province that are separated approximately by the Colorado River and I-70. Other publications refer to the southern province as the Grand Mesa Basin. Oil shale is present in both provinces, with the richest oil shale deposits in the north, and smaller, isolated deposits in the south.

3.2.1.2 Geologic Setting

Within the Piceance Basin, the upper bedrock stratigraphy consists of a series of basin-fill sediments from the Tertiary period (Topper et al. 2003). The uppermost unit is the Uinta Formation, which consists of up to 1,400 ft of Eocene-age sandstone, siltstone, and marlstone. Below the Uinta Formation is the Eocene Green River Formation, which can be up to 5,000 ft thick and includes four members: the Parachute Creek (keragenous dolomitic marlstone and shale), the Anvil Points (shale, sandstone, and marlstone), the Garden Gulch (claystone, siltstone, clay-rich oil shale, and marlstone), and the Douglas Creek (siltstone, shale, and sandstone) members. The Eocene-Paleocene Wasatch Formation underlies the Green River Formation. The Wasatch is a shale and sandstone formation. Below the Wasatch is the Cretaceous Mesaverde Group (sandstone and shale), the Cretaceous Mancos Shale, and older sedimentary formations atop Precambrian rock.

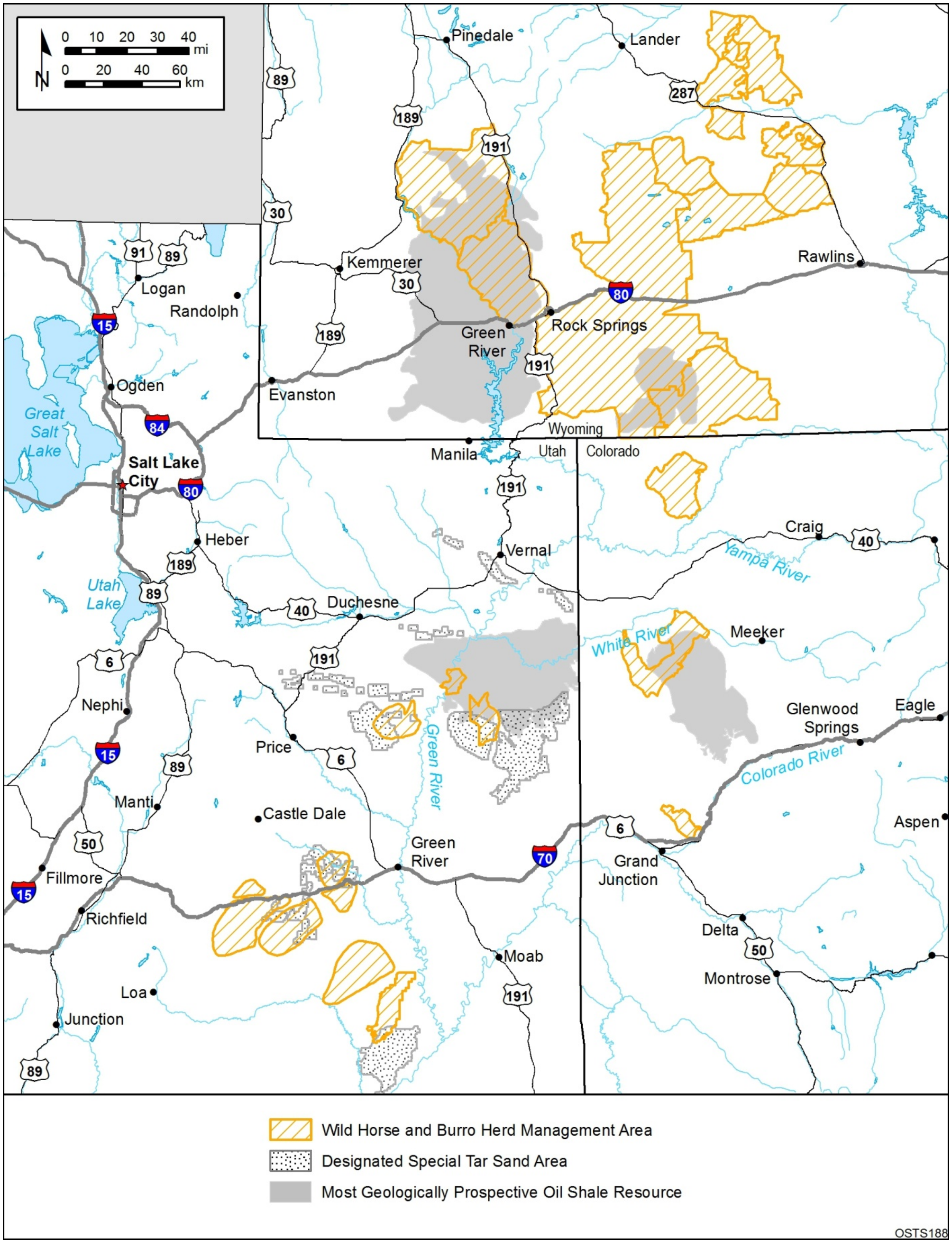

FIGURE 3.1.3-1 Distribution of Wild Horse and Burro Herd Management Areas within the Oil Shale and Tar Sands Study Area

The main oil shale members of interest in the Piceance Basin are the Parachute Creek and Garden Gulch Members. The grade of oil shale varies with location and depth, but the Parachute Creek Member has the richest material and includes the Mahogany Zone.

Quaternary alluvium of varying thickness is present in the significant drainages of the basin. The alluvium can provide sand and gravel resources for construction projects, and the alluvium aquifers are often important sources of groundwater.

3.2.1.3 Soils

Soils in the Piceance Basin vary in their thickness and character (DOI 1973). On upland areas, soils are generally rocky with shallow depth to bedrock. Slopes in these areas are typically 10 to 60%. Eolian deposits (silt) may blanket the upland surface. Deep alluvial soils are found in drainageways and in valleys, with slopes less than 10%. Locally, valleys may contain colluvium from the side slopes. Erosion occurs mainly along roads and trails and in stream valleys. Intermittent creeks show head cutting, bank cutting, and deep gullying. Summer storms may cause bridge washouts and flash floods with extensive sheet erosion.

Biological soil crusts (also known as cryptobiotic crusts) may occur locally on undisturbed soils. The crusts are made of various algae, bacteria, mosses, and fungi. These crusts reduce wind and water erosion, fix atmospheric nitrogen, and contribute to organic soil matter. On upland ridges and cliffs, soil formation is minimal because of steep slopes and strong winds. Erosion due to a lack of vegetative cover and/or overgrazing is mainly by wind and has exposed thin loamy soils. Gullying is possible in small drainageways, as is mass wasting of weathered soil and rock.

The dissolution of salts in soil results in salinity problems for surface waters. This is described in Section 3.4.1.2.

3.2.1.4 Seismicity and Landslide Susceptibility

Seismic risk in the Piceance Basin is fairly low according to the USGS, with a peak acceleration of about 5% of gravity, with a 10% probability of occurrence in 50 years, and a peak acceleration of 14 to 16% of gravity, with a 2% probability of occurrence in 50 years (Frankel et al. 2002).

Landslide risk has been mapped by the USGS (Radbruch-Hall et al. 1982). In the Piceance Basin, the susceptibility of the landscape to landslides is generally high, though the incidence of landslides in the basin is low (less than 1.5% of the area involved) in most of the basin.

3.2.1.5 Mineral Resources

In addition to oil shale, the Piceance Basin contains the sodium minerals halite, dawsonite, and nahcolite, which are intermingled with the oil shale. Nahcolite is sodium bicarbonate and may be used as soda ash, to remove sulfur from industrial air emissions, and as a cattle feed supplement. It occurs in the Parachute Creek Member at proportions generally less than 5% by weight; however, in the lower oil shale zone it may average more than 30% by weight (DOI 1973). Dawsonite is dihydroxy sodium aluminum carbonate and is found in the lower portion of the northern province of the Piceance Basin. It is a source of alumina, and some intervals contain up to 3% by weight of equivalent extractable alumina (DOI 1973). Interbedded halite and oil shale are found in a sequence in the northern province of the Piceance Basin. The halite beds range from 1 to 30 ft in thickness (DOI 1973). Recoverable amounts of these minerals are estimated by the BLM (1983a) for several individual tracts of land within the basin. An area near the northern edge of the Piceance Basin that measures more than 100 mi^2 is referred to as the Multimineral Zone. Here, the BLM does not allow oil shale development without suitable recovery of sodium minerals. In a surrounding area set aside for sodium leasing, sodium mineral extraction is not allowed to damage oil shale units.

Oil, natural gas, and coal are also present in the Piceance Basin (DOI 1973). The most productive zone is at the base of the Green River Formation and the underlying Cretaceous Mesaverde Group. Extensive natural gas drilling has taken place in the southern portion of the northern Piceance province. Coal underlies essentially the entire basin (DOI 1973).

3.2.2 Uinta Basin

3.2.2.1 Physiography

The overall Uinta Basin has an area of about 7,000 mi^2, bounded by the Uinta Mountains to the north, the Wasatch Range to the west, the Roan Cliffs to the south, and the Douglas Creek Arch to the east (Cashion 1967). The basin is almost entirely in Utah, with a small portion of the overall basin extending into Colorado. The Uinta Basin is a structural, depositional, and topographic/drainage basin. This description focuses on the study area located in the geologically prospective east-central portion of the Uinta Basin (Figure 1.2-1). This region is primarily in Uintah County, Utah, with a small western extension into Duchesne County, Utah.

3.2.2.2 Geologic Setting

The Uinta Basin contains a thickness of up to 15,000 ft of lacustrine and fluvial sedimentary rock of Eocene age above older sedimentary formations (Cashion 1967).

The uppermost bedrock unit is the Duchesne River Formation of fluvial sandstone and shale. Below this formation is the Uinta Formation of similar lithologies. Below the Uinta is the Green River Formation, which is composed of four members. The uppermost is the Evacuation

Creek Member (also commonly known as the Uinta–Green River Transition), which is composed mainly of marlstone and siltstone and interfingers with the overlying Uinta Formation. The underlying Garden Gulch and Parachute Creek Members are of similar lithologies. The Parachute Creek Member is the main oil shale–bearing member, and includes the rich Mahogany Zone. The Douglas Creek Member is composed of mixed lithologies, including sandstone, siltstone, and limestone, and it interfingers with the overlying Garden Gulch and Parachute Creek Members and the underlying Wasatch Formation. The Wasatch is also an Eocene-age basin-fill unit and is composed of sandstone and shale.

Quaternary alluvium is present along the Uinta Basin's major stream valleys. The alluvium can provide sand and gravel resources for construction projects, and the alluvium aquifers are often important sources of groundwater.

3.2.2.3 Soils

Soils in the Uinta Basin are in two general groupings on the basis of the geomorphological setting (DOI 1973). Most of the basin's flat areas are covered with shallow soils over weathered bedrock. These soils are typically either fine loam or silt over silty or clayey subsoils, or sandy or coarse loamy soils. Shale and/or sandstone bedrock is usually about 20 in. deep. Erosion is high during summer storms.

Along the floodplains and terraces of major rivers are deep loamy or silty soils over coarser subsoils. Erosion through stream cutting is high during high flow periods.

The dissolution of salts in soil results in salinity problems for surface waters. This is described in Section 3.4.1.2.

Overall, the basin's erosion potential is critically high, although some areas are in the slight to moderate range, and some areas have erosion potential that is considered severe.

Biological soil crusts occur on undisturbed soils in some portions of Utah and may be found in the study area. The crusts are made of various algae, bacteria, mosses, and fungi. These crusts reduce wind and water erosion of the soils, fix atmospheric nitrogen, and contribute to soil organic matter (BLM 2002c).

3.2.2.4 Seismicity and Landslide Susceptibility

Seismic risk in the Uinta Basin is fairly low according to the USGS, with a peak acceleration of about 6 to 7% of gravity, with a 10% probability of occurrence in 50 years, and a peak acceleration of about 14 to 18% of gravity, with a 2% probability of occurrence in 50 years (Frankel et al. 2002).

Landslide risk has been mapped by the USGS (Radbruch-Hall et al. 1982). In the Uinta Basin, the susceptibility of the landscape to landslides is low, as is the incidence of landslides (less than 1.5% of the area involved).

3.2.2.5 Mineral Resources

Gilsonite, a black, brittle natural petroleum residue, is found in the Uinta Basin. Numerous vertical veins up to 7 mi long and 18 ft wide are found in the prospective oil shale area (Cashion 1967). Along the southern portion of the study area, part of the prospective oil shale area overlaps two STSAs—Hill Creek and P.R. Spring. Oil and gas have been produced from the lower part of the Green River Formation, the Wasatch Formation, and deeper Mesozoic-age rocks. Oil and natural gas are also present in the Unita Basin.

3.2.3 Green River Basin and Washakie Basin

3.2.3.1 Physiography

The Green River and Washakie Basins are located in the Wyoming Basin Physiographic Province of the Rocky Mountain Region. The oil shale areas are surrounded by the Wasatch, Green, Uintah, and Seminoe Mountains and by the Wind River and Medicine Bow Ranges. The overall basin has an area of about 6,700 mi^2. This description focuses on the study areas located within the Green River and Washakie Basins (Figure 1.2-1).

The Green River Basin is mainly bounded by escarpments of the Green River and Wasatch Formations (Mason and Miller 2004). The Washakie Basin is a synclinal structure with faulting mainly along its southern and western edges. Its central portion has few faults (DOI 1973). The rim of the basin is formed by rock of the Green River Formation (Mason and Miller 2004).

3.2.3.2 Geologic Setting

The Green River and the Washakie Basins are separated by the Rock Springs uplift. Each contains sedimentary rock with thicknesses of more than 20,000 ft.

In the Green River Basin, the uppermost unit is the Bridger Formation of fluvial and paludal (marsh) origin (Roehler 1992). The underlying Green River Formation is mostly lacustrine basin-fill rock. The uppermost member of the Green River Formation is the Luman Tongue, a unit of mudstone, sandstone, shale, oil shale, and coal over 200 ft thick. The Tipton Shale Member contains the Scheggs Bed (oil shale with sandstone, siltstone, and other lithologies) and the Rife Bed (oil shale interbedded with dolomite and tuff), totaling over 150 ft in thickness. The Wilkins Peak Member contains oil shale, shale, mudstone, siltstone, and sandstone, and is about 1,000 ft thick. The underlying Laney Member is about 1,300 ft thick and includes the LaClede Bed (oil shale and shale with interbedded siltstone, shale, and tuff), the Sand Butte Bed (sandstone and siltstone), and the Hartt Cabin Beds (mudstone, shale, dolomite, sandstone, and siltstone). The Wasatch Formation underlies the Green River Formation and is mostly fluvial and paludal material. The Green River Formation intertongues with both the overlying Bridger Formation and the underlying Wasatch Formation; it is replaced by these formations, and, in some locations around the basin, by the fluvial Battle Spring Formation.

In the Washakie Basin the stratigraphy is similar; however, the uppermost unit is referred to as the Washakie Formation rather than the Bridger Formation (Roehler 1992). The Green River Formation here is composed of four units. The uppermost, the Laney Member, is up to 1,300 ft thick and consists of sandstone, siltstone, and mudstone, with generally low-grade oil shale zones. The Wilkins Peak Member is about 400 ft thick. Its upper portion is mudstone, siltstone, and sandstone, with minor amounts of oolitic and algal limestone and thin beds of low-grade oil shale. The lower portion is mainly low-grade to moderate-grade oil shale with algal limestone and siltstone. The Tipton Member is about 200 ft thick and is made up of low- to moderate-grade oil shale with some algal limestone and siltstone. The Luman Tongue is about 300 ft thick and is the lowermost unit of the Green River Formation. Its upper half is mainly low-grade oil shale with some limestone. The lower half is interbedded siltstone, sandstone, mudstone, low-grade oil shale, thin units of moderate-grade oil shale, limestone, shale, and coal.

3.2.3.3 Soils

The soils of the Green River and Washakie Basins are developed on the Green River, Bridger, and Wasatch Formations (DOI 1973). The soils' textures range from sandy to loamy to clayey. The soil surfaces are mainly level or moderately sloping, though roughly 20% of the area has steep slopes. Sixty percent of the basin area has shallow soil, with the bedrock within 20 in. of the surface. Erosion rates are generally moderate to high. Because of the aridity, wind erosion is often greater than water erosion. Biological soil crusts may occur locally on undisturbed soils. The crusts are made of various algae, bacteria, mosses, and fungi. These crusts reduce wind and water erosion, fix atmospheric nitrogen, and contribute to soil organic matter.

The dissolution of salts in soil results in salinity problems for surface waters. This is described in Section 3.4.1.2.

3.2.3.4 Seismicity and Landslide Susceptibility

Seismic risk in the Green River Basin is fairly low according to the USGS, with a peak acceleration of about 5% of gravity, with a 10% probability of occurrence in 50 years, and a peak acceleration of about 18 to 22% gravity, with a 2% probability of occurrence in 50 years (Frankel et al. 2002). In the Washakie Basin, the seismic risk is also fairly low, with a peak acceleration value of about 7 to 8% of gravity, with a 10% probability of occurrence in 50 years, and a peak acceleration of about 16 to 20% of gravity, with a 2% probability of occurrence in 50 years.

Landslide risk has been mapped by the USGS (Radbruch-Hall et al. 1982). In the Green River Basin, the susceptibility of the landscape to landslides is low in most areas, but high along the edges of the Flaming Gorge Reservoir and in an area northeast of the City of Green River. The incidence of landslides in the basin is low (less than 1.5% of the area involved) in most areas, but moderate (1.5 to 15% of the area) in a portion of the basin near the City of Green River and in a small zone in the southwestern portion of the basin. The Washakie Basin's susceptibility to landslides is approximately evenly split between low and moderate areas. The incidence of landslides is low (less than 1.5% of the area).

3.2.3.5 Mineral Resources

According to the DOI (1973), sodium minerals have not been discovered in the Washakie Basin. The central Green River Basin, however, has economic deposits of trona and halite in the Wilkins Peak Member of the Green River Formation (Roehler 1992). Approximately 500 m^2 in the central Green River Basin are designated as the MMTA. Oil and natural gas are present in the Wasatch, Fort Union, and Mesaverde Formations and have been produced in commercial quantities at locations surrounding the Washakie Basin (DOI 1973). These formations underlie the basin at depths several thousand feet below the lowermost Green River Formation oil shales. Coal is also present below the oil shale in the Green River and Washakie Basins (DOI 1973; Mason and Miller 2004).

3.2.4 Special Tar Sand Areas

3.2.4.1 Physiography

Seven of the STSAs (Argyle Canyon, Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, Raven Ridge, and Sunnyside) are located in the Uinta Basin (Figure 1.2-2). The physiographic setting in Section 3.2.2.1 applies to these sites.

The four STSAs in southeast-central Utah (San Rafael, Circle Cliffs, Tar Sand Triangle, and White Canyon) are in the Canyonlands section of the Colorado Plateau physiographic province (BLM 1984b) (Figure 1.2-2). San Rafael is located on the San Rafael Swell; White Canyon is on the northwest flank of the Abajo Mountains; Circle Cliffs is an upland area between the Aquarius Plateau and the Henry Mountains; and the Tar Sand Triangle is located at the southern end of the San Rafael Desert.

3.2.4.2 Geologic Setting

The seven northern STSAs (Argyle Canyon, Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, Raven Ridge, and Sunnyside) are located in the Uinta Basin, and most are in Tertiary-age sedimentary rocks. The geologic description in Section 3.2.3.2 applies to most of these sites. The exception is Asphalt Ridge, which is partially in the Cretaceous Mesaverde

Formation (BLM 1984b). The rock units containing the tar are mostly fluvial sandstones, though some are lacustrine sediments. The bitumen is usually concentrated in the coarser facies of the sediments.

The four southern STSAs (San Rafael, Circle Cliffs, Tar Sand Triangle, and White Canyon) have bedrock of Permian and Triassic ages (BLM 1984b). The Tar Sand Triangle is in the Permian White Rim Sandstone, which may be dune sand or shallow marine sand deposits. Bitumen varies at the STSA along with the variations in sand texture and permeability. The Circle Cliffs and San Rafael STSAs are located in the lower Moenkopi Formation. This unit is a large deltaic deposit of fine- to medium-grained, moderately well-sorted sandstone of Triassic age. The White Canyon STSA occurs in the Hoskininni Sandstone, a Triassic shallow marine deposit.

3.2.4.3 Soils

Soils at the 11 STSAs have a wide range of thicknesses and character because of spatially varying factors such as parent material, climate, topography, and vegetation. Data compiled by the BLM (1984b) indicate general conditions in mountainous areas (moist, dark or light) and valley or mesa areas (dry, light-colored). The soils are developed from sandstone, shale, and siltstone bedrock and have corresponding textures (e.g., sandy soils near more resistant ridges, clayey soils near shale outcrops). Alluvial fan soils are loamy and bouldery. Slopes vary within individual STSAs and among different STSAs.

The BLM (1984b) has evaluated the erosion potential of the STSA soils in terms of sediment yield classification. Overall, the largest category of the STSA land area is that of moderate sediment yield (0.2 to 0.5 ac-ft/mi^2/yr), followed by high sediment yield (0.5 to 1.0 ac-ft/mi^2/yr).[6] The San Rafael STSA had the only significant amount of land area (18%) at a very high sediment yield (1.0 to 3.0 ac-ft/mi^2/yr).

Biological soil crusts occur on undisturbed soils in some portions of Utah and may be found in the study area. The crusts are made of various algae, bacteria, mosses, and fungi. These crusts reduce wind and water erosion of the soils, fix atmospheric nitrogen, and contribute to soil organic matter (BLM 2002c).

3.2.4.4 Seismicity and Landslide Susceptibility

Seismic risk among the STSAs varies with location, with the westernmost STSAs having higher risk than the others. Argyle Canyon, San Rafael, and Circle Cliffs have peak acceleration of roughly 10% of gravity with a 10% probability of exceedance in 50 years (Frankel et al. 2002). At the other eight STSAs, the seismic risk is lower, with peak acceleration values ranging from about 4 to 7% of gravity.

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6 An acre-foot is the volume of water that covers 1 acre (43,560 ft^2) to a depth of 1 ft (0.3 m).

Landslide risk varies among the 11 STSAs. At most of the northern STSAs (Argyle Canyon, Pariette, Sunnyside, Hill Creek, P.R. Spring, and Raven Ridge), the susceptibility to landslides is low, and the incidence of landslides is low (less than 1.5% of the area) (Radbruch-Hall et al. 1982). The other northern STSA, Asphalt Ridge, is the same, except along its northern edge, where the incidence is moderate (1.5 to 15% of the land). At the San Rafael Swell, the incidence is low, and the susceptibility is approximately half low and half moderate across the scattered parcels of land. The Circle Cliffs STSA has low incidence in most of its area, but high incidence (more than 15% of the mapped area) in narrow bands along the western and eastern edges of the STSA. Landslide susceptibility here, however, is low. The White Canyon STSA's land area is a mix of low, moderate, and high incidence, and low-to-moderate susceptibility. The Tar Sand Triangle STSA has low landslide incidence but mostly moderate landslide susceptibility.

3.2.4.5 Mineral Resources

Other mineral resources are present or possibly present at the 11 STSAs (BLM 1984b). Oil and gas are present at P.R. Spring and Pariette, and are likely at Hill Creek and Raven Ridge. Oil and gas are possible, though not highly likely, at Argyle Canyon, Asphalt Ridge, Circle Cliffs, and White Canyon.

Oil shale of significant thickness and yield overlies the tar sands deposits along the northern edge of the P.R. Spring and Hill Creek STSAs. The Mahogany Oil Shale Zone is present at the Pariette and Raven Ridge STSAs; however, these oil shale deposits are not included in the oil shale study area defined for this PEIS, because they are of lower quality.

Coal of potential commercial thickness and quality occurs below the Sunnyside STSA; it is at a depth that would require underground rather than surface mining. Any potential coal beds in cretaceous rocks under the Hill Creek, P.R. Spring, and Asphalt Ridge STSAs would not likely be minable.

Uranium may occur locally above the Moenkopi Formation in the Shinarump Conglomerate Member of the Chinle Formation at the Circle Cliffs, Tar Sand Triangle, and White Canyon STSAs, and at the San Rafael STSA.

Copper occurs locally at the San Rafael STSA.

3.3 PALEONTOLOGICAL RESOURCES

Paleontological resources are the fossilized remains of ancient life forms, their imprints, or behavioral traces (e.g., tracks, burrows, residues), and the rocks in which they are preserved. These are distinct from human remains and artifacts, which are considered archaeological or historical materials. Fossil energy resources, such as coal and oil, are also generally excluded from the definition of paleontological resources.

Fossils have scientific and educational value because they are important in understanding the history of life on Earth and the biodiversity of the past, and in developing new ideas about ecology and evolution. On public lands, vertebrate and uncommon invertebrate and plant paleontological resources may only be collected for scientific and educational purposes under a permit. Common invertebrate and plant fossils may be collected for recreational use, but cannot be bartered or sold. Petrified wood is a mineral material that may be collected recreationally in limited amounts, or collected commercially under a mineral material contract.

Various statutes, regulations, and policies govern the management of paleontological resources on public lands. Recently Congress passed a paleontology law, entitled *Paleontological Resources Preservation Act under the Omnibus Public Lands Act of 2009*. The law establishes four main points: (1) paleontological resources collected under a permit are U.S. property and must be available for scientific research and public education; (2) the nature and location of paleontological resources on public lands must be kept confidential to protect those resources from theft and vandalism; (3) theft and vandalism of paleontological resources on public lands can result in civil and criminal penalties, including fines and/or imprisonment; and (4) curation of paleontological resources from federal lands in an approved repository. The law also requires an expansion of public awareness and education regarding the importance of paleontological resources on public lands and the development of management plans for inventory, monitoring, and scientific and educational use of paleontological resources (BLM 2009).

Additional statutes for management and protection include the *Federal Land Policy and Management Act of 1976* (FLPMA) (P.L. 94–579, codified at 43 USC 1701–1782). *Theft of Government Property and Destruction of Government Property* (18 USC 642 and 1361 statutes), which penalize the theft or degradation of property of the U.S. government, may be used to supplement the criminal penalties under 16 USC 470aaa-5. Other federal acts—the *Federal Cave Resources Protection Act* (P.L. 100–691, 102 Stat. 4546; codified at 16 USC 4301) and the *Archaeological Resources Protection Act* (16 USC 470aa et seq.)—protect fossils found in significant caves and/or in association with archeological resources.

The large number of productive fossil-bearing geological formations found on federal land in the American West has encouraged the BLM to provide guidance on protecting this resource. Two Instruction Memoranda (IM) have been issued by the BLM to provide guidelines on implementing a Potential Fossil Yield Classification (PFYC) system for paleontological resources on public lands (IM 2008-009) (BLM 2007c) and for assessing potential impacts on paleontological resources (IM 2009-011) (BLM 2008b).[7] Under the PFYC system, geologic units are classified from Class 1 to Class 5 on the basis of the relative abundance of vertebrate

[7] Formerly, the 2000 report by the Secretary of the Interior on Fossils on Federal Land (DOI 2000) provided guidance on the treatment of paleontological resources. Further guidance was provided in the BLM Manual 8270, *Paleontological Resource Management* (BLM 1998). Procedures for managing these resources were identified in an attachment to BLM Manual 8270, the Paleontological Resources Handbook H-8270-1, *General Procedural Guidance for Paleontological Resource Management.* These guidance documents have been superseded in part by the expanded and clarified guidance available in BLM's Instruction Memoranda IM 2008-009 and IM 2009-011.

fossils or uncommon invertebrate or plant fossils and their sensitivity to adverse impacts. A higher classification number indicates a higher fossil yield potential and greater sensitivity to adverse impacts. Table 3.3-1 provides a description of the five PFYC classes and the corollary management direction indicated for each class.

TABLE 3.3-1 Potential Fossil Yield Classification Descriptions

Class	Description	Basis	Management Direction
1	Geologic units that are not likely to contain recognizable fossil remains, including igneous and metamorphic units (excluding tuffs) and units that are Precambrian in age or older (i.e., older than 540 million years before present).	The potential for impacting any fossils is negligible. The occurrence of significant fossils is nonexistent or extremely rare. No assessment or mitigation of paleontological resources is needed.	Land manager's concern for paleontological resources is negligible or not applicable. No assessment or mitigation needed except in very rare cases.
2	Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant invertebrate fossils. These include geologic units in which vertebrate fossils or uncommon invertebrate or plant fossils are unknown or very rare, units that are younger than the Pleistocene Epoch (10,000 years before present), aeolian deposits, and units exhibiting significant diagenetic alteration.	The potential for impacting vertebrate fossils or uncommon invertebrate or plant fossils is low. Localities containing important resources may exist, but would be rare and would not influence the classification. Management actions are not likely to be needed.	Land manager's concern for paleontological resources is low. No assessment or mitigation needed except in rare cases.
3	Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential. These include units in which vertebrate fossils and uncommon invertebrate or plant fossils are known to occur inconsistently (i.e., predictability is low), units of marine origin with sporadic known occurrences of vertebrate fossils, and poorly studied or poorly documented units (i.e., potential yield cannot be assessed without ground reconnaissance).	This classification encompasses a broad range of potential impacts, including geologic units of unknown potential and units of moderate or infrequent fossil occurrence.	Land manager's concern for paleontological resources is moderate, or cannot be determined from existing data. Surface-disturbing activities may require field assessment to determine a further course of action.

TABLE 3.3-1 (Cont.)

Class	Description	Basis	Management Direction
4	Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or uncommon invertebrate or plant fossils (as in Class 5), but have lowered risks of human-caused adverse impacts or natural degradation. These include units with extensive soil or vegetative cover or with limited bedrock exposures, areas in which exposed outcrop is less than 2 contiguous acres, and areas in which exposed outcrops form cliffs of sufficient height and slope to minimize impacts.	The potential for impacting vertebrate fossils or uncommon invertebrate or plant fossils is moderate to high and is dependent on the proposed action. The geologic unit is considered a Class 5, but the risk of potential impacts is reduced by the presence of a protective layer of soil, thin alluvial material, or other mitigating circumstance.	Land manager's concern for paleontological resources is moderate to high, depending on the proposed action. A field survey and assessment by a qualified paleontologist are often needed to assess local conditions. Approval from the authorized officer is required for project to proceed. Resource preservation and conservation through controlled access or special management designation should be considered. Mitigation may be necessary before and/or during these actions. On-site monitoring may also be necessary during construction activities.
5	Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or uncommon invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation. Vertebrate fossils or uncommon invertebrate or plant fossils are known and documented to occur consistently, predictably, or abundantly. Units are exposed, with little or no soil or vegetative cover. Outcrop areas are extensive; exposed bedrock areas are larger than 2 contiguous acres.	The potential for impacting significant fossils is high. Vertebrate fossils or uncommon invertebrate or plant fossils are known or can be expected to occur.	Land manager's concern for paleontological resources is high. A field survey and assessment by a qualified paleontologist is required in advance of surface-disturbing activities or land tenure adjustments. Approval from the authorized officer is required for project to proceed. Resource preservation and conservation through controlled access or special management designation may be appropriate. Mitigation will often be necessary before and/or during these actions. On-site monitoring may also be necessary during construction activities.

Source: BLM (2006i).

An overview report by Murphey and Daitch (2007) describing significant paleontological resources in the oil shale and tar sands study areas was prepared in support of the 2008 PEIS. The descriptions in the following sections are based on this report. Table 3.3-2 provides a summary of the programmatic-level sensitivities of geologic units within each of the basins that could potentially be affected by oil shale or tar sands development. Sensitivity maps (1:500,000 scale) showing areas with the highest potential for significant paleontological resources are presented in the overview report. The BLM is currently developing sensitivity maps with a finer scale.

3.3.1 Piceance Basin

Several geologic units dating from the Paleocene to the Middle Eocene (approximately 66 to 40 million years ago) within the Piceance Basin have the highest potential to contain significant paleontological resources and warrant consideration for assessing and mitigating potential impacts related to oil shale development. They include (from oldest to youngest) the Atwell Gulch, Molina, and Shire Members of the Debeque (Wasatch) Formation; the Parachute Creek Member of the Green River Formation; and the Uinta Formation (Table 3.3-2). These units are covered locally by younger surficial deposits (alluvium, colluvium, landslide deposits, and glacial drift) of Pleistocene and Holocene age that are designated PFYC Class 2.

3.3.2 Uinta Basin

Several geologic units dating from the Late Cretaceous to the Middle Eocene (approximately 100 to 40 million years ago) within the Uinta Basin have the highest potential to contain significant paleontological resources and warrant consideration for assessing and mitigating potential impacts related to oil shale development. They include (from oldest to youngest) the Mesaverde Group; the Main Body of the Wasatch Formation; the Douglas Creek Member of the Green River Formation at Raven Ridge and Nine Mile Canyon; the Parachute Creek Member of the Green River Formation; the Wagonhound and Myton Members of Uinta Formation; and the Brennan Basin and LaPoint Members of the Duchesne River (Table 3.3-2). These units are covered locally by younger surficial deposits (alluvium, colluvium, pediment deposits, landslide deposits, and glacial outwash and till) of Pleistocene and Holocene age that are designated PFYC Class 2.

3.3.3 Green River and Washakie Basins

Several geologic units dating from the Early to Middle Eocene (approximately 56 to 40 million years ago) within the Greater Green River Basin (including the Washakie Basin) have the highest potential to contain significant paleontological resources and warrant consideration for assessing and mitigating potential impacts related to oil shale development. They include (from oldest to youngest) the LaBarge Member, New Fork Tongue, Niland Tongue, Main Body, Upper Member, Cathedral Bluffs Tongue, and Hiawatha Member of the Wasatch Formation; the Laney and Fossil Butte Members of the Green River Formation; the Blacks Fork, Twin Buttes,

TABLE 3.3-2 Summary of Programmatic-Level Paleontological Sensitivities of Geologic Units within the Piceance, Uinta, and Greater Green River Basins

Geologic Unit	Age	Typical Fossils	BLM Designation[a]	PFYC Designation[b]
Piceance Basin				
Alluvium, colluvium, landslide deposits, and glacial drift	Holocene	None in deposits of Holocene age unless reworked from older sediments	Condition 3	Class 2
Alluvium, colluvium, landslide deposits, and glacial drift	Pleistocene	Scattered vertebrates, invertebrates, and plants occur locally	Condition 2	Class 2
Uinta Formation	Middle Eocene	Localized occurrences of vertebrates (mammals, reptiles), invertebrates (mollusks), and plants (leaves and wood)	Condition 1	Class 4/5
Green River Formation: Parachute Creek Member	Middle Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (insects, arthropods, and mollusks), plants (leaves, flowers, and wood), and ichnofossils	Condition 1	Class 4/5
Green River Formation: Anvil Points and Garden Gulch Members	Early Eocene	Vertebrates (mostly fish), invertebrates (mollusks), and plants (leaves)	Condition 2	Class 3
DeBeque (Wasatch Formation), Atwell Gulch, Molina and Shire Members	Paleocene and Early Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (mollusks), and plants	Condition 1	Class 4/5
Uinta Basin				
Alluvium, colluvium, landslide deposits, pediment deposits, glacial outwash, and till	Holocene	None in deposits of Holocene age unless reworked from older sediments	Condition 3	Class 2

TABLE 3.3-2 (Cont.)

Geologic Unit	Age	Typical Fossils	BLM Designation[a]	PFYC Designation[b]
Uinta Basin (Cont.)				
Alluvium, colluvium, landslide deposits, pediment deposits, glacial outwash, and till	Pleistocene	Scattered vertebrates, invertebrates, and plants occur locally	Condition 2	Class 2
Duchesne River Formation: Brennan Basin and Lapoint Members	Middle Eocene	Vertebrate (mammal) fossil accumulations occur locally but are uncommon	Condition 2	Class 4/5
Duchesne River Formation: Dry Gulch Creek and Starr Flat Members	Middle Eocene	Vertebrate (mammal) fossils rare in Dry Gulch Member; no records of fossils in Starr Flat Member	Condition 2	Class 3
Uinta Formation: Wagonhound and Myton Members	Middle Eocene	Locally abundant vertebrates (mammals, reptiles), invertebrates (mollusks), and plants (leaves and wood)	Condition 1	Class 4/5
Green River Formation: Parachute Creek Member	Middle Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (insects, arthropods, and mollusks), plants (leaves, flowers, and wood), and ichnofossils	Condition 1	Class 4/5
Green River Formation: Douglas Creek Member	Early and Middle Eocene	Scarce vertebrates (mostly fish but also reptiles and uncommon mammals), vertebrate trackways, locally common invertebrates (mollusks) and plants (leaves)	Condition 2	Class 3 (Class 4/5 at Raven Ridge and Nine Mile Canyon)
Wasatch Formation: Renegade Tongue	Middle Eocene	Scattered, poorly preserved vertebrates and plants (leaves and wood)	Condition 2	Class 3
Wasatch Formation: main body	Paleocene and Early Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (mollusks), and plants	Condition 1	Class 4/5

TABLE 3.3-2 (Cont.)

Geologic Unit	Age	Typical Fossils	BLM Designation[a]	PFYC Designation[b]
Uinta Basin (Cont.)				
Mesaverde Group	Late Cretaceous (Santonian and Campanian)	Moderately abundant terrestrial and marine vertebrates (fish, amphibians, reptiles, including dinosaurs, mammals), invertebrates (mollusks), and terrestrial plants	Condition 1	Class 4/5
Greater Green River Basin				
Alluvium, colluvium, landslide deposits, sand dune deposits, pediment deposits, and alluvial fan deposits	Holocene	None in deposits of Holocene age unless reworked from older sediments	Condition 3	Class 2
Alluvium, colluvium, landslide deposits, sand dune deposits, pediment deposits, and alluvial fan deposits	Pleistocene	Scattered vertebrates, invertebrates, and plants occur locally	Condition 2	Class 2
Browns Park Formation	Middle and Late Miocene	Vertebrates (mammals and turtles) rare; mammal tracks have also been reported; silicified wood is locally common	Condition 2	Class 3
Bishop Conglomerate	Late Oligocene	Rare unidentified mammal bone fragments, reworked Paleozoic invertebrates	Condition 3	Class 2
Washakie Formation: Kinney Rim and Adobe Town Members	Middle Eocene	Vertebrates (fishes, amphibians, reptiles, and mammals) locally abundant in both members; invertebrates (mollusks) and plants (wood) locally common	Condition 1	Class 4/5
Bridger Formation: Blacks Fork, Twin Buttes, Turtle Bluff Members	Middle Eocene	Vertebrates (fishes, amphibians, reptiles, birds, and mammals) locally abundant; invertebrates (mollusks) and plants (wood and leaves) locally common; insect and vertebrate ichnofossils also present	Condition 1	Class 4/5

TABLE 3.3-2 (Cont.)

Geologic Unit	Age	Typical Fossils	BLM Designation[a]	PFYC Designation[b]
Greater Green River Basin (Cont.)				
Green River Formation: Laney and Fossil Butte Members	Early and Middle Eocene	Vertebrates (fishes, amphibians, reptiles, birds, and mammals) locally abundant; invertebrates (insects, arthropods, and mollusks), plants, ichnofossils locally abundant	Condition 1	Class 4/5
Green River Formation: Luman Tongue, Fontenelle Tongue, Tipton Shale Member, Wilkins Peak Member, Angelo Member	Early and Middle Eocene	Uncommon but locally present vertebrates (fishes, reptiles, and mammals), scattered plants, locally common invertebrates (mollusks and ostracods)	Condition 2	Class 3
Wasatch Formation: LaBarge Member, New Fork Tongue, Niland Tongue, Main Body, Upper Member, Cathedral Bluffs Tongue, Hiawatha Member	Mostly Early Eocene, Cathedral Bluffs Tongue is Early and Early-Middle Eocene	Locally abundant vertebrates (fishes, amphibians, reptiles, birds, and mammals), plants, invertebrates (mollusks), and ichnofossils	Condition 1	Class 4/5
STSAs				
Alluvium, colluvium, slope wash, and landslide deposits	Holocene	None in deposits of Holocene age unless reworked from older sediments	Condition 3	Class 2
Alluvium, colluvium, slope wash, and landslide deposits	Pleistocene	Scattered vertebrates, invertebrates, and plants occur locally	Condition 2	Class 2
Chinle Formation: Temple Mountain, Shinarump, Monitor Butte, Moss Back, Petrified Forest, Owl Rock, and Church Rock Members	Upper Triassic	Locally occurring vertebrates (fishes, amphibians, and reptiles), plants, and invertebrates	Condition 2	Class 4/5

TABLE 3.3-2 (Cont.)

Geologic Unit	Age	Typical Fossils	BLM Designation[a]	PFYC Designation[b]
STSAs				
Moenkopi Formation: Black Dragon and Torrey and Moody Canyon Members	Lower and Middle Triassic	Locally occurring vertebrates (fishes, amphibians, and reptiles), plants, and invertebrates	Condition 2	Class 3
Moenkopi Formation: Sinbad Limestone Member	Lower Triassic	Locally abundant marine invertebrates	Condition 3	Class 2
Kaibab Limestone	Upper Permian	Locally abundant marine invertebrates	Condition 3	Class 2
Cutler Group, Cutler Formation undivided, Halgaito Formation	Upper Pennsylvanian and Permian	Locally occurring vertebrates (fishes, amphibians, and reptiles), plants, and invertebrates	Condition 2	Class 3
Organ Rock Formation: Cutler Group, Cedar Mesa Sandstone, White Rim Sandstone, De Chelly Sandstone	Upper Pennsylvanian and Permian	Uncommon vertebrates and invertebrate ichnofossils	Condition 2	Class 2

a BLM designations are defined as follows: Condition 1, areas known to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils; Condition 2, areas with exposures of geologic units or settings that have high potential to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils; and Condition 3, areas that are very unlikely to produce vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils on the basis of their surficial geology (e.g., igneous or metamorphic rocks; extremely young alluvium, colluvium, or eolian deposits; or the presence of deep soils).

b See Table 3.3-1 for PFYC descriptions.

Source: Adapted from Murphey and Daitch (2007).

and Turtle Bluff Members of the Bridger Formation; and the Kinney Rim and Adobe Town Members of the Washakie Formation (Table 3.3-2). These units are covered locally by younger surficial deposits (alluvium, colluvium, landslide deposits, sand dune deposits, pediment deposits, and alluvial fan deposits) of Pleistocene and Holocene age that are designated PFYC Class 2.

3.3.4 Special Tar Sand Areas

Several geologic units of Upper Triassic age (approximately 235 to 202 million years ago) within the STSAs have been classified as having the highest potential to contain significant paleontological resources and warrant consideration for assessing and mitigating potential impacts related to tar sands development. They include the Temple Mountain, Shinarump, Monitor Butte, Moss Back, Petrified Forest, Owl Rock, and Church Rock Members of the Chinle Formation (Table 3.3-2). These units are covered locally by younger surficial deposits (alluvium, colluvium, slope wash, and landslide deposits) of Pleistocene and Holocene age that are designated PFYC Class 2.

3.4 WATER RESOURCES

The oil shale basins and STSAs in this PEIS are located within the Upper Colorado River Basin. Specifically, the oil shale is present in the White River hydrologic basin in Colorado, the Uinta Basin in Utah, and the Green River Basin in Wyoming. The STSAs are situated in the Uinta and West Colorado River Basins in Utah. Colorado's Piceance Basin, where the oil shale occurs, is located in the White River hydrologic basin. Similarly, the geologic Green River and Washakie Basins are in the hydrologic Green River Basin.

Water use in the Colorado River Basin is highly developed, allocated, and regulated. In describing the water resources related to oil shale and tar sands development, it is appropriate to describe the Upper Colorado River Basin as a whole, with emphasis on hydrologic basins where the oil shale and tar sands are located. This is because intra- and interbasin water transfers are common in the region, and water allocation of the Upper Colorado River Basin Compact is prescribed by state and not by hydrologic basin. In the following subsections, important aspects of the legal framework related to water resources are introduced. The existing groundwater and surface water resources, water quality, current water uses, and resource constraints within each oil shale basin or STSA are described.

3.4.1 Legal Framework of the Upper Colorado River Basin

3.4.1.1 Water Allocation

The use of the Colorado River Basin water is shared by many states and Mexico. On the basis of the Colorado River Compact of 1922, the Colorado River Basin is divided into the Upper Colorado River Basin and Lower Colorado River Basin at Lees Ferry (just below the confluence of the Paria River and the Colorado River near the Utah-Arizona boundary). The upper basin and the lower basin were each apportioned a consumptive use of 7.5 million ac-ft of water annually, based on an assumption of 17.5 million ac-ft of virgin flow for the Colorado River. The assumption was demonstrated to be an overestimate and reduced to 15 million ac-ft in a hydrologic study by the BOR (BOR 1988; CWCB 2004) by using historical data collected from 1906 and 1986. This assumes that the upper Colorado Basin states are obligated to deliver 7.5 million ac-ft to the lower basin states and 0.75 million ac-ft to Mexico. The hydrologic determination study (BOR 1988) concluded that the Upper Basin states could have 6 million ac-ft of water and rarely triggered water calls from the Lower Basin States. The 6 million ac-ft is assumed for analyses in this PEIS. In the Upper Colorado River Basin Compact of 1948, the water of the Upper Colorado River Basin was further allocated among the states of Arizona, Colorado, New Mexico, Utah, and Wyoming. Arizona has a fixed allocation of 50,000 ac-ft annually. The remainder is shared by Colorado (51.75%), New Mexico (11.25%), Utah (23%), and Wyoming (14%) (DOI 2005). If the other Upper Basin States do not use their full allocation, Colorado is entitled to use those states' unused shares in a given year.

3.4.1.2 Basin Salinity and Surface Water Quality

Salinity is a key water quality issue in the basin. The major sections of the CWA that relate to salinity control are Section 302 (Water Quality Related Effluent Limitations), Section 303 (Water Quality Standards), Section 313 (Federal Facilities Pollution Control), Section 401 (State Certification of Federal Permits), Section 402 (NPDES), and Section 404 (Permits for Dredged or Fill Material). In 1973, to support compliance with Section 303 requirements to establish water quality standards and implementation plans, the CRBSCF was formed, including the Basin States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. In 1974 Congress enacted the Colorado River Basin Salinity Control Act (P.L. 93-320). In addition, in 1974, the EPA enacted a regulation setting forth the basinwide salinity control policy for the Colorado River Basin. In 1975 the CRBSCF proposed, the Basin States adopted, and the EPA approved water quality standards for the Colorado River Basin, including numeric criteria, and a plan of implementation to control salinity increases in the Colorado River. In 1984 Congress amended the Colorado River Basin Salinity Control Act (P.L. 98-569) and directed the BLM to implement a comprehensive program to minimize salt loading in the Colorado River Basin.

In 1995 P.L. 104-20 authorized the BOR to implement a basinwide approach to salinity control throughout the Colorado River Basin in its Salinity Control Program. The new authorities also allow the BOR to respond quickly to time-sensitive opportunities provided by other cost-sharing partners (states and federal agencies), resulting in the implementation of more cost-effective measures for salinity control. Since 1995, the BOR has solicited proposals and awarded funds to various salinity control projects under its Basinwide Salinity Control Program. This program continues to assist with projects for controlling salinity, including funding landowners who install salinity control measures.

The BLM coordinates salinity control activities with the CRBSCF, the Basin States, the BOR, and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). These agencies receive Congressional funding for salinity control. Other federal agencies that have a stake and participate in the CRBSCF Work Group meetings include the EPA, USFWS, and USGS.

The BLM has conducted ongoing salinity control activities to minimize salt loading from BLM-administered lands within the Upper Colorado River Basin since 1973. Point-source controls were implemented beginning in FY 1974. The BLM created a four-person salinity team to evaluate landscape processes and land management actions relevant to the Colorado River Basin salinity during the period 1975 to 1984. Non–point-source control activities began in 1980, following intensive studies of salt occurrence and salt behavior on arid rangelands (BLM 1987c).

In addition, prior to 1984, the USDA conducted salinity control activities as part of the Agricultural Conservation Program administered by the Agricultural Stabilization and Conservation Service and the Soil Conservation Service. P.L. 98-569 authorized the USDA Colorado River Salinity Control Program (CRSCP) through mid-1996. The 1996 Farm Bill, P.L. 104-127, combined the CRSCP into the Environmental Quality Incentives Program (EQIP). EQIP was reauthorized through 2007 under the 2002 Farm Bill (P.L. 107-171). The goals of these programs are to minimize salt loading in the Colorado River Basin and to offset the effects of additional water development (DOI 2005).

Salinity has long been recognized as one of the major problems of the river (CRBSCF 2005). The river carries an average salt load of approximately 4.4 million tons annually past Lees Ferry, Arizona. It is estimated that BLM-administered lands in the Upper Colorado River Basin contribute about 700,000 tons of salt a year from surface runoff. The remaining 3.7 million tons are contributed primarily by groundwater inflow and saline springs, and runoff from other federal, tribal, state, and private lands (DOI 2005).

The sources of salinity in the basinwide Colorado River were estimated to be 47% from natural sources, 37% from irrigation, 12% from reservoir leaching, and 4% from municipal and industrial activities. In 2004, the salinity control programs for the BOR, USDA, and the BLM prevented a total of 1,072,000 tons of salts from entering the river. A goal has been set to prevent an additional 728,000 tons/yr from entering the river by 2025 basinwide (DOI 2005).

The quality of the surface water in the four oil shale basins generally declines from their headwaters in the mountain areas to the basins. As the Colorado River reaches the basins where sedimentary rocks dominate, more soluble minerals containing sodium, sulfate, and chloride become available, resulting in an increase of dissolved salt and sediment (USGS 1968). Urban development in the basins and heavy agricultural uses of surface water in areas underlain by shaley sedimentary rocks also contribute to the increase of dissolved salt and sediment content in surface water bodies (Spahr et al. 2000).

The BLM's efforts to reduce salt loading due to activities conducted on BLM-administered lands would be applicable to future oil shale and tar sands development activities. The agency has developed a strategy to be implemented through its RMPs that primarily relies on best management of the basic resource base, including identifying targeted watersheds with high salt loading, improving vegetation cover to reduce surface runoff and soil erosion on rangelands, and proper land uses. In addition, the BLM has developed a water source inventory to identify saline springs in the basin (DOI 2005).

3.4.1.3 Impaired Streams under the Clean Water Act

Under the CWA, each state is required to establish and maintain water quality standards to protect, restore, and preserve its water quality. In addition to numerical water quality standards, states also establish narrative criteria that include designated, specific chemical and biological criteria necessary for protecting designated uses, and an antidegradation policy. When a lake, river, or stream fails to meet the narrative criteria, Section 303(d) of the CWA directs the state to place the water body on the 303(d) list of "impaired" waters. Water quality criteria called Total Maximum Daily Load (TMDL) are often developed for impaired waters. A TMDL establishes the maximum amount of a pollutant allowed in the water while maintaining all of its designated beneficial uses.

Table 3.4.1-1 lists the impaired water bodies located within and upstream of the target oil shale basins and STSAs in 2012. In Colorado, several streams in the Piceance Basin have become further impaired in recent years. Since 2006, four stream segments in the Colorado oil shale basin were added to the 303(d) list for failing to meet Fe (Trec) or aquatic life standards (CDPHE 2012a). Impaired streams in the oil shale and tar sands areas in Utah do not meet the total dissolved solids (TDS) water quality standard; Colorado and Wyoming do not have a TDS water quality standard. Other stream segments in the oil shale and tar sands areas of Utah are not meeting the selenium, boron, arsenic, temperature, and/or benthic-macroinvertebrate bioassessment standards. Many of the stream segments in Utah have been newly recognized as impaired since the 2008 PEIS was published, indicating a recent decline in water quality in the Unita Basin. Fecal coliform is the major impairment in the Green River Basin in Wyoming; the source remains unknown. Stream segments in the Green River Basin also do not meet the *E. coli*, chloride, pH, and habitat alteration standards. There have been no new stream segments added to the 303(d) list in the Green River Basin since 2006.

3.4.1.4 Water Use

Data for water use provided by the states and the BOR are generally organized by watersheds or hydrologic basins. The boundaries of these hydrologic basins do not necessarily coincide with the geologic basins (such as the Piceance Basin, Green River Basin, Uinta Basin, and Washakie Basin), although the same names are used. Generally, the geologic Piceance Basin is inside the hydrologic White River Basin. The geologic oil shale Uinta Basin is within the hydrologic Uinta Basin. The hydrologic Green River Basin covers an area that includes both the geologic Green River Basin and the Washakie Basin. The STSAs are located within the hydrologic Uinta Basin and the West Colorado River Basin in Utah.

In the following discussion, the water uses in each hydrologic basin of the Upper Colorado River Basin are provided by state for the municipal and industrial (M&I), self-supplied industry (SSI), and agricultural sectors. These data are useful because the water allocation in the Upper Colorado River Compact is based on individual states. Water demand and consumptive use, as well as availability by state, can then be compared. In addition, major streamflows within the areas where the oil shale is located are also listed. The streamflow data can be used to compare with the possible water needs for oil shale or tar sands development (see Sections 4.5 and 5.5), and to demonstrate whether interbasin water transfer is likely to occur. The water use data listed in this section cover 2000 as the base year and projected water use in 2030 for Colorado and Wyoming, and in 2050 for Utah,[8] taking into account population and industrial

[8] The water availability is projected to different years based on the availability of projection data from the three states.

TABLE 3.4.1-1 Water-Impaired Stream Segments in Oil Shale Basins and STSAs in 2012

Hydrologic Basin	Subbasin	Hydrologic Unit Code	Stream	Location	Cause of Impairment
Oil Shale					
Colorado					
White River Basin	Piceance Basin	COLCWH13c	Yellow Creek	Mainstream of Yellow Creek from immediately below the confluence with Barcus Creek to the confluence with the White River	Fe (Trec), aquatic life
		COLCWH14a	Piceance Creek	Mainstream of Piceance Creek from the source to a point just below the confluence with Hunter Creek	Fe (total recoverable)
		COLCWH15	Piceance Creek	Mainstream of Piceance Creek from Ryan Gulch to the confluence with the White River; the Dry Fork of Piceance Creek, from Little Reigan Gulch to Piceance Creek	Aquatic life (provisional)
		COLCWH20	Black Sulphur Creek	Mainstreams of Black Sulphur Creek from the source to Piceance Creek	Aquatic life (provisional)
Utah					
Uinta Basin	Ashly-Brush Basin	UT14060002-001_00	Lower Ashley Creek and tributaries[a]	Ashley Creek and tributaries from Green River confluence to Vernal sewage lagoons	TDS
		UT14060002-002_00	Middle Ashley Creek and tributaries[a]	Ashley Creek and tributaries from Vernal sewage lagoons to Dry Fork confluence	Selenium, TDS
		UT14060002-003_00	Brush Creek and tributaries[a]	Brush Creek and tributaries from confluence with Green River to Red Fleet Dam but excluding Little Brush Creek	Selenium
		UT14060002-008_00	Lower Dry Fork Creek and tributaries[a]	Dry Fork and tributaries from confluence with Ashley Creek to USFS boundary	Temperature
	Duchesne Basin	UT14060003-002_00	Duchesne River-2 and tributaries[a]	Duchesne River and tributaries from confluence with Uinta River to Myton	Temperature
		UT14060003-005_00	Antelope Creek and tributaries[a]	Antelope Creek and tributaries from Duchesne River confluence to headwaters	Boron, TDS

TABLE 3.4.1-1 (Cont.)

Hydrologic Basin	Subbasin	Hydrologic Unit Code	Stream	Location	Cause of Impairment
Utah (Cont.)					
		UT14060003-006_00	Duchesne River-3[a]	Duchesne River from Myton to Strawberry River confluence	Benthic-macroinvertebrate bioassessments
	Lower Green – Desolation Canyon Basin	UT14060005-002_00	Pariette Draw Creek and tributaries	Pariette Draw Creek and tributaries from Green River confluence to headwaters	Boron, selenium, TDS
	Lower White	UT14050007-003_00	Evacuation Creek	Evacuation Creek and tributaries from the confluence with White River to headwaters	TDS
	Strawberry Basin	UT14060004-001_00	Strawberry River-1[a]	Strawberry River from confluence with Duchesne River to Starvation Dam	Boron
		UT14060004-002_00	Indian Canyon Creek and tributaries[a]	Indian Canyon Creek and tributaries from Strawberry River confluence to headwaters	Arsenic, boron, TDS
		UT14060004-005_00	Avintaquin Creek and tributaries[a]	Avintaquin Creek and tributaries from Strawberry River confluence to headwaters	Arsenic
	Willow Basin	UT14060006-001_00	Willow Creek and tributaries	Willow Creek and tributaries from Green River confluence to Meadow Creek confluence (excluding Hill Creek)	Benthic-macroinvertebrate bioassessments
Wyoming					
Green River Basin	Bitter Creek Basin	WYGR140401050506_01	Bitter Creek	Bitter Creek from the confluence with the Green River upstream to Point of Rocks	Chloride
		WYGR140401050808_01	Killpecker Creek[a]	Killpecker Creek from the confluence with Bitter Creek upstream to Reliance	Fecal coliform
	Blacks Fork Basin	WYGR140401070106_01	Blacks Fork[a]	Blacks Fork from the confluence with the Smiths Fork upstream to Millburne	*E. coli*
		WYGR140401070205_01	Willow Creek[a]	Entire Willow Creek watershed upstream of the confluence with the Smiths Fork	Habitat alterations

TABLE 3.4.1-1 (Cont.)

Hydrologic Basin	Subbasin	Hydrologic Unit Code	Stream	Location	Cause of Impairment
Wyoming (Cont.)					
		WYGR140401070208_00	Smiths Fork[a]	Smiths Fork from the confluence with Cottonwood Creek upstream to the confluence with East and West Forks Smiths Fork	Fecal coliform
		WYGR140401070208_01	Smiths Fork[a]	Smiths Fork from the confluence with the Blacks Fork upstream to the confluence with Cottonwood Creek	Habitat alterations, *E. coli*
		WYGR140401070403_01	Blacks Fork	Blacks Fork from the confluence with the Hams Fork upstream to the confluence with the Smiths Fork	Fecal coliform
		WYGR140401070701_01	Hams Fork[a]	Hams Fork from below the Kemmer-Diamondville WWTF to a point 7.6 mi downstream	pH
Special Tar Sands Areas (only those with impaired stream segments are listed)					
Utah (Uinta Basin)					
Argyle Canyon	Duchesne Basin	UT14060003-005_00	Antelope Creek and tributaries	Antelope Creek and tributaries from Duchesne River confluence to headwaters	Boron, TDS
	Strawberry Basin	UT14060004-002_00	Indian Canyon Creek and tributaries	Indian Canyon Creek and tributaries from Strawberry River confluence to headwaters	Arsenic, boron, TDS
		UT14060004-005_00	Avintaquin Creek and tributaries	Avintaquin Creek and tributaries from Strawberry River confluence to headwaters	Arsenic
Hill Creek	Willow Basin	UT14060006-001_00	Willow Creek and tributaries	Willow Creek and tributaries from Green River confluence to Meadow Creek confluence (excluding Hill Creek)	Benthic-macroinvertebrate bioassessments
Pariette	Lower Green – Desolation Canyon Basin	UT14060005-002_00	Pariette Draw Creek and tributaries	Pariette Draw Creek and tributaries from Green River confluence to headwaters	Boron, selenium, TDS
P.R. Spring	Willow Basin	UT14060006-001_00	Willow Creek and tributaries	Willow Creek and tributaries from Green River confluence to Meadow Creek confluence (excluding Hill Creek)	Benthic-macroinvertebrate bioassessments

TABLE 3.4.1-1 (Cont.)

Hydrologic Basin	Subbasin	Hydrologic Unit Code	Stream	Location	Cause of Impairment
Utah (Uinta Basin) (Cont.)					
Sunnyside	Lower Green – Desolation Canyon Basin	UT14060005-003_00	Ninemile Creek and tributaries	Ninemile Creek and tributaries from Green River confluence to headwaters	Temperature
Utah (Colorado River West Basin)					
San Rafael	San Rafael Basin	UT14060009-013_00	San Rafael River	San Rafael River from Buckhorn Crossing to confluence of Huntington and Cottonwood Creeks	Benthic-macroinvertebrate bioassessments
San Rafael	San Rafael Basin	UT14060009-014_00	San Rafael River	San Rafael River from confluence with Green River to Buckhorn Crossing	Benthic-macroinvertebrate bioassessments

[a] Stream segment is upstream of study area.

Sources: CDPHE (2012a); UDEQ (2010a); WDEQ (2012a).

growth and changes in the agricultural landscape, excluding potential water needs for oil shale or tar sands development.

Tables 3.4.1-2 to 3.4.1-4 display the water demand (or diversion) and the water consumption (or depletion) in Colorado, Utah, and Wyoming in the Upper Colorado River Basin. These tables do not include instream uses or water needs of ESA-listed fishes. The data for water demand from water bodies or groundwater wells are from state agencies (CWCB 2004; SWWRC 2001a,b; UDNR 1999, 2000a,b, 2001; BOR 2004).

Water diversion is the amount of water withdrawn from a water body (stream or reservoir) or a well (groundwater). The amount of water diverted in the Upper Colorado River Basin is commonly much larger than the amount of water actually consumed, because a portion of the diverted water is lost during delivery through evaporation to the air and leakage to the subsurface, and some also returns to the water body as return flow. Consumptive use is defined as the portion of the diverted water that does not return to the stream system. In general, consumptive use is assumed in the calculations for apportioning water in the Upper Colorado River Basin Compact.

The M&I sector indicates residential, commercial, institutional, and industrial uses in Colorado. M&I water demand is closely related to the size of the human population. In urban areas, diverted M&I water is used. Wastewater is created and is treated before being discharged back to a water body. The water actually consumed is less than the water delivered. In Colorado, the ratio (consumptive use rate) for M&I is about 35% (CWCB 2004).

Industries in the SSI sector, such as power plants or mining companies, could consume a large amount of water. The SSI industries generally have their own water supplies. In some instances, SSIs may use M&I water in addition to their own primary water supply. In the oil shale basins of Colorado and Wyoming, power generating plants and soda mining are important SSI industries that contribute relatively high consumptive use rates. In power generating plants, a large amount of water is used for cooling. The amount used depends on the cooling system of the power generating plants and may vary considerably. The consumptive use rate for SSI in Moffat County in northwestern Colorado (primarily from two power generating plants and the soda mining industry) is about 76%. The rate is derived by comparing the amount of water diverted with actual water consumption data in 2000 provided by the state (CWCB 2004) and BOR (2004).

In the agricultural sector, reported consumptive use (to support the calculations apportioning water in the Upper Colorado River Compact) is calculated differently in Colorado and Utah than in Wyoming. Colorado and Utah report consumptive use as the water that does not return to surface water bodies. However, Wyoming reports irrigation depletion separately and does not consider return water, and thus may overestimate actual consumptive use due to irrigation. Irrigation depletion and consumptive use are calculated by models with input of acreages of agricultural land, types of crop, and weather data.

Generally, water demand in the Upper Colorado River Basin cannot be totally met because the availability of water is limited by physical streamflow conditions, water rights

TABLE 3.4.1-2 Colorado Water Demand and Consumptive Use in 2000 and 2030

	Demand (ac-ft/yr)			Consumptive Use (ac-ft/yr)		
		2030[a]			2030[a]	
Location	2000	Low	High	2000	Low	High
Colorado Basin						
M&I and SSI[b]	73,975	100,975	145,193	25,891	35,341	50,818
Agriculture[b,c]	1,764,000	1,644,000	1,706,000	582,120	542,520	562,980
Export[d]	759,800	759,800	759,800	759,800	759,800	759,800
Dolores/San Juan/San Miguel						
M&I and SSI[b]	23,629	33,369	46,030	5,900	11,679	16,111
Agriculture[b,c]	953,000	948,000	962,000	368,200	312,840	317,460
Export[d]	–176200	–176200	–176200	–176,200	–176,200	–176,200
Gunnison Basin						
M&I and SSI[b]	20,688	29,044	38,849	7,241	10,165	13,597
Agriculture[b,c]	1,705,000	1,640,000	1,689,000	562,650	541,200	557,370
Export[d]	0	0	0	0	0	0
Yampa/White/Green						
M&I and SSI[b]	29,408	45,262	56,880	17,800	28,830	36,230
Agriculture[b,c]	642,000	627,000	852,000	194,000	206,910	281,160
Export[d]	1,800	1,800	1,800	1,800	1,800	1,800
Total reservoir evaporation[e]	389,575	389,575	389,575	389,575	389,575	389,575
Grand total	6,186,675	6,042,625	6,470,927	2,738,777	2,664,460	2,810,700
Legally available[f]				3,079,125	3,079,125	3,079,125
Percentage of legally available allocated to sectors				88.9	86.5	91.3
Water surplus				340,348	414,665	268,425

Footnotes on next page.

TABLE 3.4.1-2 (Cont.)

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[a] Assumes irrigated acreage change in 2030 ranges from –2,600 acres (due to urbanization of irrigated lands) to +39,000 acres (assumes a firm supply of water and funding sources provided).

[b] Includes delivery system loss, irrigation water requirement, incident losses, and stock pond evaporation.

[c] The consumptive use factors for M&I and agricultural are 0.35 and 0.33, respectively. The factors were derived from year 2000 data from BOR (2004) and CWCB (2004).

[d] Diversion was measured: a negative value means import, a positive value means export. Include Gunnison and the Dolores Rivers (BOR 2004). Assumes export does not change in 2030.

[e] Evaporation from main stem reservoirs of the Upper Colorado River Basin and the reservoirs in northwestern Colorado (using last 10 years average).

[f] Assumes 6,000,000 ac-ft/yr available for Upper Colorado River Upper Basin based on long-term historical data from 1906 to 1986.

Sources: CWCB (2004); BOR (1988, 2004).

TABLE 3.4.1-3 Utah Water Demand and Consumptive Use in 2000, 2020, and 2050

Location	Demand (ac-ft/yr)			Consumptive Use (ac-ft/yr)		
	1996/2000[a]	2020	2050	1996/2000[a]	2020	2050
Southeastern Colorado River Basin						
M&I and SSI[b,c]	8,740	10,000	12,000	5,990	6,800	8,160
Agricultural[d]	73,000	73,000	72,000	43,255	42,295	41,095
Uinta Basin	2000	2020	2050	1995/2000	2,020	2,050
M&I and SSI[a]	15,830	20,360	30,850	8,450	10,870	16,210
Agricultural[d,e]	745,000	744000	741,000	387,400	386,880	385,320
Export	150,400	150,400	150,400	150,400	150,400	150,400
Western Colorado River Basin	1996/2000[a]	2020	2050	1996/2000[a]	2,020	2,050
M&I and SSI[b]	55,168	70,300	79,300	43,400	56,200	62,200
Agricultural[d,f]	284,000	283,000	281,000	156,200	181,120	179,000
Export/Import[c]	4,640	79,640	160,280	4,640	79,640	160,280
Groundwater source[g]	–17,871	–17,871	–17,871	–17,871	–17,871	–17,871
Evaporation[h]				53,250	53,250	53,250
Main stem reservoir evaporation[i]				137,402	137,402	137,402
Total water use	1,318,907	1,412,829	1,508,959	972,516	1,086,986	1,175,446
Legally available				1,368,500	1,368,500	1,368,500
Projected use as percentage of legally available				71.1%	79.4%	85.9%
Water surplus				395,984	281,514	193,054

[a] In the southeastern and western Colorado River Basin, M&I and SSI are from 1996 data and agricultural water is from 2000 data; in Uinta Basin, agricultural water is from 1995 data, while M&I and SSI are from 2000 data. Source: UDNR (2000a).

[b] Sources: UDNR (1999; 2000a,b).

Footnotes continued on following page.

TABLE 3.4.1-3 (Cont.)

[c] Consumptive use in 2020 and 2050 was estimated by multiplying the demand by a factor of 0.68. The factor was derived from the 1996 data.

[d] Agricultural water use information is from UDNR (2001). Southeastern Colorado River Basin includes 24,825 ac-ft of Flaming Gorge Water Right; exports of 50,000 ac-ft from water right on the Fremont River in Wayne County and 25,000 ac-ft near Green River in Emery and Grand Counties, 5,400 ac-ft from Price River drainage to the Sevier River Basin; 70,000 ac-ft of water from Lake Powell to Washington County, and 6,000 ac-ft from Lake Powell to Kane County.

[e] The consumptive use was estimated by multiplying the demand by a factor of 0.52. The factor was derived from data provided in UDNR (1999).

[f] The consumptive uses were estimated by multiplying the demand by factors of 0.55, 0.64, and 0.64 for 2000, 2020, and 2050. The factors were derived from data provided in UDNR (2000b).

[g] Yield of the West Colorado River Basin is 630,000 ac-ft/yr; the Navajo Sandstone Aquifer may store several million ac-ft of groundwater.

[h] Based on average of 10 years evaporation for Utah in the Upper Colorado River Basin.

[i] 23% of the average of 10 years main stem evaporation. The main stem evaporation includes major reservoirs shared by several states.

[j] Assumes 6,000,000 ac-ft/yr available for Upper Colorado River Upper Basin; Utah's share is 23% of 5,950,000 ac-ft.

Sources: UDNR (1999, 2000a,b, 2001).

TABLE 3.4.1-4 Wyoming Water Demand and Consumptive Use in 2000 and 2030

	Demand (ac-ft/yr)				Consumptive Use[b] (ac-ft/yr)
		2030[a]			
Location	2000	Low	Moderate	High	2000
Green River Basin					
Surface water					
Municipal	6,542	6,628	8,059	10,068	
SSI (power generation + soda ash + others)	66,460	77,960	106,400	166,300	
Municipal and industrial					45,900
Agricultural[c]	401,000	408,000	423,000	438,000	326,700
Export[d]	17,200	22,700	22,700	22,700	17,200
Evaporation from state water bodies	32,300	32,300	32,300	32,300	32,300
Main-stem reservoir evaporation[e]	83,636	83,636	83,636	83,636	83,636
Surface water subtotal	607,138	631,224	676,095	753,004	505,736
Legally available[f]	833,000	833,000	833,000	833,000	833,000
Projected use in percentage of legally available	72.89	75.78	81.16	90.40	60.71
Water surplus	225,862	201,776	156,905	79,996	327,264
Groundwater use					
Municipal	811	927	1,065	1,140	
Domestic	1,940–3,880	2,100	3,600	5,080	
SSI (oil and gas, coalbed methane, mining)[g]	0	0	0	0	
Groundwater subtotal	2,751–4,691	3,027	4,665	6,220	

[a] Low-growth scenario depends on cattle price (or foliage price), population growth, and industrial growth. Sources: BOR (2004); SWWRC (2001b).

[b] Source: BOR (2004).

Footnotes continued on following page.

TABLE 3.4.1-4 (Cont.)

[c] Depletion is used for agricultural consumptive use, resulting in a higher number than the BOR's estimate. Source: SWWRC (2001a).

[d] A diversion from the upper Little Snake River Basin to the City of Cheyenne. Source: SWWRC (2001b).

[e] Assumes 14% of 597,400 ac-ft (yearly average of the last 10 years of four major reservoirs).

[f] Assumes 6,000,000 ac-ft/yr available for Upper Colorado River Upper Basin.

[g] The groundwater pumped by these industries is returned to the subsurface; no consumptive use.

Sources: SWWRC (2001a,b); BOR (2004).

(physically and legally available water, respectively), and lack of storage facilities. In addition, infrastructure for storage (reservoirs) and delivery systems is required to send physically and legally available water to end users. In many agricultural areas, the lack of financial resources often limits the construction of infrastructure, thereby reducing potential agricultural water use. This results in a disparity between high water demand and relatively lower consumptive water use. The infrastructure also dictates water supply availability.

Both intra- and interbasin water transfers are common in Colorado and Utah. Water from the upper reaches of the Colorado River is transferred to the South Platte and Arkansas hydrologic basins (or Front Range) to support metropolitan and agricultural water needs. Similarly, water from the Uinta Basin is transferred to central Utah. Because the water is exported outside the Upper Colorado River Basin, the total amount exported is considered to be a consumptive use.

Evaporation of water from reservoirs and other water bodies contributes a large portion of consumptive water use in the Upper Colorado River Basin. The evaporation is from four major reservoirs (Flaming Gorge, Blue Mesa, Morrow Point, and Lake Powell) along the main stem of the river, and from smaller reservoirs, stock ponds, and streams within each state.

Although groundwater is commonly used in the four basin areas, most of the groundwater is drawn from alluvium adjacent to the major streams (Repplier et al. 1981). In Colorado, water from the shallow alluvial aquifer is considered part of the surface water (tributary water). For deeper aquifers (nontributary water), withdrawal of groundwater is considered to be consumptive use if it is not returned to the subsurface (BOR 2004). Environmental and recreation water use to maintain instream flows are not considered consumptive water use.

As shown in Table 3.4.1-2, the demand for water in Colorado in the Upper Colorado River Basin was more than 6,000,000 ac-ft in the year 2000. The projected demands for the year 2030 also exceed 6,000,000 ac-ft. The projected demands are based on projected population decrease or growth in the region as well as the transfer of part of the agricultural water to the M&I sector, with an assumption that water conservation practices remain at existing levels. The state used two scenarios to project future use to 2030. The low water use projection is based on an assumed 5% reduction of water use per capita, 5% reduction of population, and 10% water conservation in those counties with identified self-supplied water. The high water use projection, instead, assumes a 5% increase of water use per capita, 5% increase in population, and 10% increase of water use in those counties with identified self-supplied water use. Both the 2000 and projected future water demands well exceed the legally allocated water of 3,079,125 ac-ft specified in the Upper Colorado River Compact of 1948. On the other hand, the existing and projected consumptive uses of water in the 2000 and 2030 range from 2,664,000 to 2,810,000 ac-ft, or about 87 to 91% of the legally allocated water. The projected values do not include the water demand for oil shale and/or tar sands development. A more recent report includes similar estimates for consumption for the years 2008 and 2035, with additional estimates for 2050 (low, middle, high estimates) (CWCB 2011).

In addition, recovery of ESA-listed fishes in the Upper Colorado River Basin depends in part upon adequate instream flows in the Colorado River and its tributaries. The Colorado River

Endangered Fishes Program and the USFWS have evaluated the flow requirements for these fishes. Appendix I lists the instream flow requirements set by the CWCB for streams within the oil shale study area in Colorado.

In Utah, projected water use data provided by the state's water plan are for 2020 and 2050 rather than 2030. Table 3.4.1-3 lists existing and projected water demands and consumptive uses, not considering the water use of any oil shale and/or tar sands development. Similar demand estimates for the Uinta basin from UDNR (2003) are 24,000 ac-ft/yr in 1995; 31,000 ac-ft/yr in 2050 without conservation measures; and 26,000 ac-ft/yr in 2050 with conservation measures. A comparison of the Table 3.4.1-3 water demands and Utah's allocated water under the Upper Colorado River Basin Compact shows that the projected demands in 2020 and 2050 are less than the allocated water. The projected consumptive use of water potentially reaches about 79% and 86% of the allocated water in the 2020 and 2050, respectively.

In Wyoming, water data for consumptive use are provided by the state and BOR (Table 3.4.1-4). In the state estimates, the consumptive agricultural water use is defined as the total irrigated water (i.e., return flow water was not subtracted from the irrigated water, resulting in a higher amount of consumptive use water estimated by the state than by the BOR; see Table 3.4.1-4, year 2000 data). Nevertheless, the projected consumptive use water is less than 90% of the allocated water specified by the Upper Colorado River Basin Compact of 1948. The low, moderate, and high water use scenarios in Table 3.4.1-4 are based on the scenarios of cattle price, population growth, and industrial growth.

In 2005, the BOR's *Quality of Water: Colorado River Basin, Progress Report No. 22* (DOI 2005) also estimated the depletion of the water due to full basin development for the main stem of the Upper Colorado River Basin. The projections were made in consultation with individual states and the Upper Colorado River Commission. The remaining amount of water available and the percentages of state share available for development are shown in Table 3.4.1-5. The projected water consumption of each state by the BOR is much larger than that projected by the states.

Although a certain amount of water is calculated to be available in Wyoming and Utah and to a lesser extent in Colorado, this does not imply that the water is readily or physically available for development. Oil shale basins and STSAs are situated in much smaller areas, as compared with the size of the hydrologic Upper Colorado River Basin by which the water availability was calculated. In addition, hydrologic basins enriched with surplus water resources are not necessarily coincident with the oil shale basins and STSAs. Storage infrastructure and delivery systems have to be built to capture water for use. In addition, water rights and water storage rights (for reservoirs) have to be transferred or purchased before the water can be used for development, because most of the water and storage rights have been claimed in the Upper Colorado River Basin. Finally, water use for the development must meet different state and federal regulations, including requirements to protect instream flows for endangered Colorado River fishes in the basin. All in all, whether enough water is available for development depends on the results of intensive negotiations between various parties, including water right owners, state and federal agencies, and municipal water providers, as well as the developers.

TABLE 3.4.1-5 Upper Colorado Basin Depletion Projections[a]

	1,000 ac-ft/yr			
Locations	2010	2020	2030	2040
Colorado				
State share	3,079	3,079	3,079	3,079
Remaining available	204	158	109	81
Percentage of state share available	7%	5%	4%	3%
Utah				
State share	1,369	1,369	1,369	1,369
Remaining available	240	194	120	72
Percentage of state share available	18%	14%	9%	5%
Wyoming				
State share	833	833	833	833
Remaining available	244	225	189	145
Percentage of state share available	29%	27%	23%	17%

[a] States do not necessarily concur with the projections adopted by the BOR for planning purposes.

Source: DOI (2005).

3.4.2 Piceance Basin

3.4.2.1 Groundwater Resources

As discussed in Section 3.2.1, the upper bedrock stratigraphy within the Piceance Basin, consists of a series of basin-fill sediments from the Tertiary period. Hydrogeologically, the Tertiary units are grouped into aquifers and confining units (Czyzewski 2000; Topper et al. 2003; Weeks et al. 1974; Robson and Saulnier 1981). The Uinta Formation and the upper portion of the Parachute Creek Member comprise the Upper Piceance Basin Aquifer. The middle of the Parachute Creek Member, however, is considered the Mahogany confining unit. This Mahogany Zone is the richest oil shale zone in the basin. The lower Parachute Creek Member is the Lower Piceance Basin Aquifer, while the Garden Gulch, Douglas Creek, and Anvil Points Members, combined, constitute another confining unit. Local variations in lithology occur at various scales and may result in permeable zones in units that are predominantly confining units and impermeable zones in units that are predominantly aquifers. The upper portion of the Tertiary Wasatch Formation is shaley and is continuous with the confining unit composed of Green River members described above. The lower Wasatch is a sandstone aquifer. The underlying Cretaceous Mesaverde Group composes the Mesaverde Aquifer, while the deeper Mancos Shale is a confining unit.

Permeability within the Upper Piceance Basin Aquifer is attributable to the primary porosity of the sandstone and fractured siltstone of the Uinta Formation and the fractured and dissolution-enhanced fractures of the Parachute Creek Member of the Green River Formation. The upper aquifer's hydraulic conductivity is approximately 1 ft/day. The aquifer's thickness is generally 250 to 1,000 ft in most of the basin. Well yields are 1 to 900 gpm; a yield of 100 gpm is common (Czyzewski 2000).

The Mahogany confining unit has an average thickness of 160 ft, but ranges up to 225 ft. Its horizontal hydraulic conductivity is reported as <0.01 ft/day. Fractures within the Mahogany Zone permit some vertical flow between the upper and lower aquifers (Czyzewski 2000). The vertical hydraulic conductivity is generally low but may increase locally due to natural vertical fractures. Locally, a different interval may be the primary confining unit separating the upper and lower aquifers reported in BLM (2006g).

The Lower Piceance Basin Aquifer's permeability is attributable to the fractured marlstone of the lower Parachute Creek Member. The lower aquifer's hydraulic conductivity is also approximately 1 ft/day, and its thickness is 500 to 1,000 ft in most of the basin. Well yields in the lower aquifer range from 1 to 1,000 gpm; yields of 200 to 400 gpm are typical (Czyzewski 2000).

Exploratory drilling in the basin has shown that groundwater in the Upper and Lower Piceance Basin Aquifers is typically contained in intervals 0.5 to 20 ft thick composed of fractured or vuggy marlstone, lean oil shale, or sandstone. In the basin, 90% of the water wells are completed to a depth of 300 ft or less, and the median reported well yield is 11 gpm.

The lower Green River Formation's confining unit separates the Lower Piceance Basin Aquifer from the Wasatch and Mesaverde Aquifer. This confining unit is 1,000 to 6,000 ft thick in the basin. The Mesaverde Aquifer has a saturated thickness of 500 to 2,000 ft. It is underlain by the Mancos Shale, which ranges up to 7,000 ft thick.

The Colorado Water Quality Control Commission established an aquifer classification system of five categories of groundwater based on chemical concentration standards and TDS. These include domestic use quality (meets state human health standards and TDS concentrations are below 10,000 mg/L), agricultural use quality (meets state agricultural health standards and TDS concentrations are below 10,000 mg/L), surface water protection quality (guards against proposed or existing activities impacting groundwater such that water quality standards for classified surface water bodies will be exceeded), potentially useable quality (TDS below 10,000 mg/L and potential future use), and limited use and quality (TDS above 10,000 mg/L) (Topper et al. 2003). Additional details on the water classification system, including specific chemical limits, are available in CDPHE (2009).

Most recharge to the basin's aquifers takes place as winter precipitation in the surrounding areas of higher elevation (Czyzewski 2000; Topper et al. 2003). In summer, high evapotranspiration rates allow little to no infiltration (Glover et al. 1998). Recharge is estimated as 0 to 2.3 in./yr, depending on ground elevation (Glover et al. 1998). The estimated total recharge to the Piceance Basin Aquifer system north of the Colorado River is about 30,400 ac-ft/yr (Topper et al. 2003).

In the northern province, groundwater discharge from the upper and lower aquifers in the Piceance and Yellow Creek drainage basins is generally as upward flow either into alluvial valley fill along creeks or as springs in the shallow valleys. In the Roan and Parachute Creek drainage basins, discharge generally occurs as springs in deep canyon walls (Czyzewski 2000; Topper et al. 2003). In the southern province, similar discharge scenarios are assumed, dependent upon local relationships among topography, hydrogeology, and water levels.

In Colorado's Piceance Basin, the principal aquifer is alluvium along major rivers (Topper et al. 2003). However, in the counties composing the basin, water use is dominated by surface water, which accounts for approximately 97% of the water usage (Topper et al. 2003). An exception is in Rio Blanco County, where groundwater is approximately 10% of the water use. In this county, which includes most of the Piceance Basin as well as large areas outside the basin, the total average annual groundwater withdrawal from bedrock and alluvial aquifers is estimated as 15,000 ac-ft, of which 88% is used in mining activities (coal, oil, and gas). Other groundwater uses in northwestern Colorado include domestic purposes, livestock watering, industry, and irrigation.

The alluvial aquifer along the White River in Colorado is mainly used for domestic purposes and for watering livestock (Topper et al. 2003). The annual amount of water pumped from this alluvium is about 1,000 ac-ft (Hatton 2000). Well yields range from 2 to 600 gpm, with an average of 50 gpm (Topper et al. 2003).

Sparse data on the White River alluvial aquifer's water chemistry suggest fair quality, with TDS from 200 to 2,500 mg/L and hardness ranging from 160 to 1,400 mg/L (Hatton 2000; Topper et al. 2003). Water with TDS levels below 1,000 mg/L is generally suitable for domestic supply, while water with TDS values below 3,000 mg/L is generally suitable for agricultural purposes (Hranac 2000). The water chemistry is calcium bicarbonate or sodium sulfate.

The Upper Piceance Basin Aquifer north of the Colorado River increases in TDS from the recharge areas (about 500 mg/L) to the discharge areas (about 1,000 mg/L) (Topper et al. 2003). The water chemistry varies from calcium carbonate to sodium carbonate, with large concentrations of sulfate. The Lower Piceance Basin Aquifer has TDS levels that increase from about 1,000 to about 10,000 mg/L along its flowpaths. The water chemistry is sodium bicarbonate. Groundwater with TDS values higher than 10,000 mg/L is considered unusable.

Surface water in the basin receives base flow from alluvial aquifers. Groundwater discharge from bedrock to alluvium, therefore, indirectly provides a portion of the water used by surface water systems (Hatton 2000).

Total groundwater storage in the northern province of the Piceance Basin is estimated as 25 million ac-ft (Czyzewski 2000). The White River alluvium between the towns of Meeker and Rangely contains an estimated 103,000 ac-ft of groundwater (Topper et al. 2003). In 1995, the total groundwater withdrawal for the five counties that compose the overall Piceance Basin amounted to nearly 46,000 ac-ft, including bedrock and alluvial aquifers. Groundwater is possibly being mined (i.e., overdrawn) in the basin, resulting in depletion of the aquifer system (Topper et al. 2003). Demand is unlikely to change (Hatton 2000).

Aquifers below the Green River Formation aquifers are generally not viable because of poor water quality and high costs associated with drilling and pumping (Czyzewski 2000).

Essentially the only groundwater users in the northern province of the Piceance Basin (apart from the White River alluvium) are ranchers. An exception during the 1970s and early 1980s was oil shale exploration; the brevity of the development period, however, left the groundwater resources essentially untouched (Czyzewski 2000). Current oil and gas development, however, may be relying on groundwater resources as allowed by water rights laws. Throughout the Piceance Basin, the Tertiary bedrock may be the only practical water resource away from rivers, significant creeks, and major alluvial aquifers.

Protection of public drinking water sources, including wellhead protection and surface water source protection, is administered by the state (CDPHE 2012b).

3.4.2.2 Surface Water Resources

Two major rivers drain the Piceance Basin in the study area: the White River and its tributaries on the north and the Colorado River and its tributaries on the south (Repplier et al. 1981). The White River and Colorado River are administered by two different Water Divisions in Colorado. Each has its own authority to administer and distribute waters, promulgate rules and regulations, and collect data on water supply. The Recovery Program for Endangered Fish of the Upper Colorado River Basin is designed to protect flow conditions needed by native endangered fishes in the Basin.

Precipitation varies greatly within the Piceance Basin and is closely related to topography. Annual precipitation, in the form of rain and snow, ranges from less than 10 in. in the Colorado River valley in western Colorado to 32 in. near the top of mountains surrounding the basin (Topper et al. 2003; Andrews 1983). Streamflows fluctuate seasonally, with the highest flow occurring in the spring as a result of snowmelt from April to June, and the minimum flow occurring in early winter. Because of rugged terrain, summer storms can result in occasional flash floods in rivers. Since agricultural lands are well developed in the valley of the Colorado River, reservoirs have been constructed for better distribution of irrigation water. Therefore, the streamflows of many rivers in the Piceance Basin are regulated.

Besides the seasonal fluctuation, the annual average flows of the Colorado River also changed with wet and dry years (CWCB 2004). During the early 1920s, the region in the Upper Colorado Basin experienced wet years. The river had an annual calculated virgin flow at Lees Ferry, Arizona, as high as 24 million ac-ft. From the mid-1950s to the mid-1960s, the average virgin annual flow dropped tremendously and was reduced to as low as 7.8 million ac-ft. The lowest annual flow of about 5.5 million ac-ft was recorded in 1934. Wet years were recorded again in the early 1980s and in 1997–1998, and reached a recorded high flow of about

24 million ac-ft in 1984. The wet years were separated by dry years in the early 1990s and early 2000s. About 8.23 million ac-ft annual flow was recorded in 2002.

Computed average annual lake evapotranspiration is roughly 30 to 36 in./yr in the basin (Topper et al. 2003). The calculated water balance, determined by subtracting the average annual lake evaporation from the average annual precipitation, ranges from a loss of 12 in./yr or more in the low, western portion of Rio Blanco County to a gain of 4 in./yr or more in mountainous eastern Rio Blanco County. In most of the county and the basin, however, the water balance ranges from a loss of 12 in./yr to a loss of 4 in./yr (Topper et al. 2003).

Several tributaries of the White River, including Yellow Creek and Piceance Creek, drain the study area (Figure 3.4.2-1) between the upstream town of Meeker and the downstream town of Rangely. Two reservoirs, the Rio Blanco Lake Reservoir and the Kenny Reservoir (or Taylor Draw Reservoir), are present along this segment of the river.

The streamflow of the White River fluctuates seasonally. High flows occur between April and July. Based on data from 1962–2011, the minimum and maximum average annual flows below the town of Meeker were 290 cubic feet per second (cfs) (in 1977) and 1,069 cfs (in 1985), respectively (USGS 2012), with an average annual flow of 655 cfs. The annual peak discharge ranged from 900 cfs (in 2002) to 6,600 cfs (in 1983) (USGS 2012). The river flows west into the Green River in Utah. The average annual flow leaving the state at the Colorado-Utah border is 590,100 ac-ft (Topper et al. 2003). During low-flow seasons, groundwater discharge contributes to part of the streamflow (Tobin 1987).

The White River Basin is sparsely populated. Management of the waters in the White River Basin is under the jurisdiction of Colorado Water Division 6. The major water use in the White River Basin is irrigation. Groundwater use is minimal. On the main stem of the White River, water has been available for appropriation. However, water rights calls occur on Piceance Creek where irrigation demands can exceed streamflows (CWCB 2002). White River water quality data from 1975–1988 are summarized by Tobin (1993).

Several tributaries of the Colorado River drain the Piceance Basin between the towns of Rifle and Grand Junction. From the east to the west, they are Parachute Creek, Roan Creek, and Plateau Creek (Figure 3.4.2-1). Multiyear studies focused on many of the creeks in the study area generated data on flow and water quality parameters (e.g., Tobin et al. 1985; Adams et al. 1986). A major reservoir, the Vega Reservoir, is present along Plateau Creek, which drains to the Colorado River from the south.

Snowmelt runoff dominates the streamflow of the upper Colorado River and is typically highest in the spring and lowest in the winter (Spahr et al. 2000). The mean annual streamflow (based on 1934 to 2006 data) near Cameo is about 3,818 cfs (USGS 2006b). However, the maximum peak streamflow is much higher at 39,300 cfs. During low-flow seasons, groundwater discharge contributes part of the streamflow (Tobin 1987).

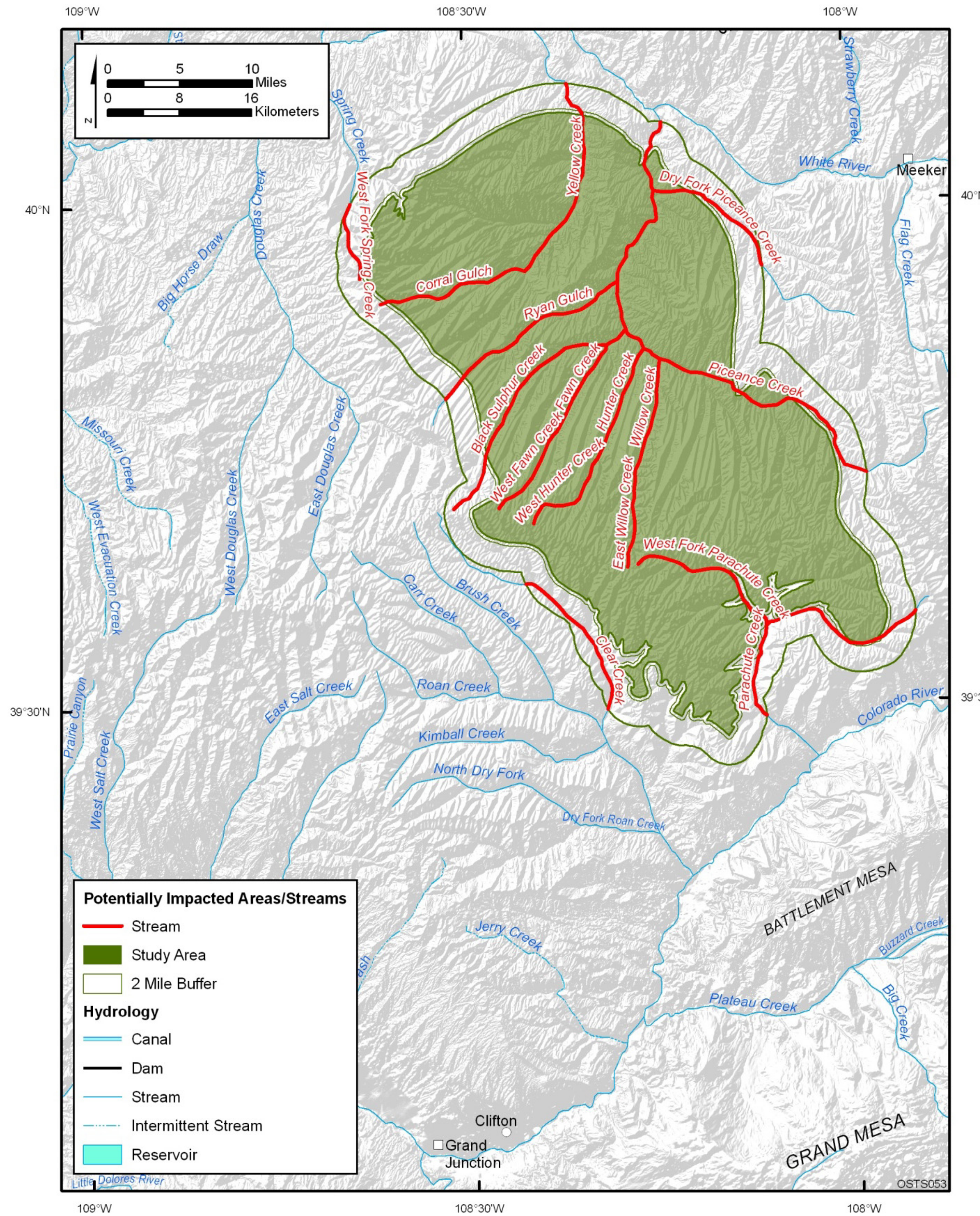

FIGURE 3.4.2-1 Yellow and Piceance Creeks and Their Tributaries in the Piceance Basin

Management of the waters in the Colorado River Basin is under the jurisdiction of Colorado Water Division 5. Irrigation accounts for 97% of the water use in the upper Colorado River; 99% of the water used is derived from surface water sources (Topper et al. 2003).

Large amounts of dissolved salts and sediment enter the Colorado River between Glenwood Springs and Cameo (USGS 1968) because local bedrock and the derived soil have relatively high contents of soluble salts. Heavy irrigation in this area also promotes the leaching process in soils, thereby releasing salts, sediments, nutrients (e.g., nitrogen and phosphorus), pesticides, and herbicides into the river (Spahr et al. 2000). Between 1914 and 1957, the Colorado River water near Cameo had flow-weighted-average concentrations of dissolved solids of 387 parts per million (ppm) and suspended sediment of 2,300 ppm (USGS 1968). Using data collected from 1970 to 1983, Bauch and Spahr (1998) found that the dissolved solids concentrations trended downward, or that no trend was indicated. Although their concentrations are typically low, pesticides are commonly detected in streams in agricultural areas (Topper et al. 2003). In the Piceance Creek subbasin of the White River Basin, Andrews (1983) claimed that 36% of the total denudation (removal of both solid particles and dissolved material) from the subbasin was as dissolved load.

3.4.3 Uinta Basin

3.4.3.1 Groundwater Resources

Section 3.2.2 describes the overall geologic framework of the Uinta Basin. Key aquifers in the basin include the alluvium, the Uinta-Duchesne Aquifer, the Parachute Creek Member of the Green River Formation (including the "Bird's Nest Aquifer"), and the Douglas Creek Aquifer of the Green River Formation.

The alluvial aquifers are recharged by infiltration of surface water and by discharge of bedrock aquifers. The average thickness of the alluvial fill in the White River and Evacuation Creek drainages is 30 ft; in the Bitter Creek drainage and elsewhere, the alluvium is about 100 ft thick. Maximum well yields are less than 1,000 gpm. Water type is typically sodium sulfate, and TDS concentrations vary from 480 to 27,800 mg/L. Most alluvial wells are along the White River, near Bonanza, where the water is used to support gilsonite mining (Holmes and Kimball 1987).

The Uinta Formation and Duchesne River Formation act as a single hydrologic unit (Glover 1996). The combined thickness of the Uinta-Duchesne Aquifer, where both units are present, is about 8,000 ft. Well yields are typically 30 to 40 gpm, but range from less than 1 gpm to as much as about 300 gpm in fractured zones. Recharge to the aquifer is mainly from infiltration of precipitation and surface water in the western extent of the formations in Duchesne and Wasatch Counties. Flow is generally to the east across the study area, with discharge to perennial streams. TDS levels range from <500 to >3,000 mg/L (Glover et al. 1998).

The Parachute Creek Aquifer is recharged by stream infiltration and leakage from the overlying Uinta Formation. It discharges to Bitter Creek and the White River. The aquifer thickness ranges from 90 to 205 ft. Water generally moves to the west from recharge areas along Evacuation Creek, and from the south and north toward the lower reaches of Bitter Creek. The "bird's nest" zone is named because in outcrops it resembles a wall of sparrows' nests. This zone contains solution cavities up to 2 ft in diameter caused by the natural removal of soluble nahcolite. Connection of the cavities has resulted in a highly permeable zone within the Parachute Creek Member. Properties of the Parachute Creek Aquifer vary greatly with location and the degree of dissolution of the nahcolite. Well yields vary also and are as high as 5,000 gpm. Water type is generally sodium sulfate to sodium bicarbonate. TDS levels range from 870 to 5,810 mg/L (Holmes and Kimball 1987).

The Douglas Creek Aquifer receives recharge mainly by infiltration of precipitation and surface water in its outcrop area, with little leakage from underlying bedrock aquifers. It discharges locally to springs in the outcrop area and to alluvium along major drainageways such as the Green and White Rivers. In the study area, flow is generally to the north and northwest. The unit is roughly 500 ft thick, although in the center of the Uinta Basin it is as thick as 1,000 ft. Maximum well yields are less than 500 gpm. Water type is typically sodium sulfate to sodium bicarbonate. TDS levels range from 640 to 6,100 mg/L (Holmes and Kimball 1987).

Groundwater in Utah is classified according to water quality and importance (State of Utah 2006). Class IA groundwater is pristine, with TDS levels less than 500 mg/L and no contaminant exceedances. Class IB groundwater is irreplaceable as a public supply source because it is a sole source of adequate quality, quantity, and economics. Class IC is ecologically important groundwater that discharges to a wildlife habitat. Class II is drinking water quality, with TDS between 500 and 3,000 mg/L and no contaminant exceedances. Class III is limited-use groundwater, with TDS between 3,000 and 10,000 mg/L and one or more contaminants exceeding groundwater quality standards. Class IV groundwater is saline, with TDS above 10,000 mg/L.

Lindskov and Kimball (1984) estimated the recoverable groundwater in storage in three main aquifers (alluvium, Parachute Creek, and Douglas Creek) in the broader southeastern Uinta Basin (an area two to three times the size of the study area) to be 18 million ac-ft. They also estimated the practical limit to groundwater withdrawal in this area as about 20,000 ac-ft/yr.

Hood and Fields (1978) provide information on water usage in the northern portion of the Uinta Basin. This area includes the northeastern part of the study area. It is assumed that their study area and the study area of this PEIS have similar water uses. They note that irrigation is the dominant water use in the region, with domestic and industrial uses being relatively small. Irrigation water for livestock and crops amounted to 575,000 ac-ft/yr from surface water and 6,000 ac-ft/yr from groundwater. In 2000, the estimated water use for irrigation in the Uinta Basin counties of Daggett, Duchesner, and Uintah was 487,000 ac-ft/yr, with some additional usage from the portions of Summit and Wasatch Counties in the basin (USGS 2011). The Hood and Fields estimates of 1974 population and water use were 28,700 persons in northern Uinta Basin counties and 12,700 ac-ft/yr of domestic use. This domestic water was almost all from wells and springs. Wells were also used to supply the industrial needs of 4,900 ac-ft/yr. In 1995, the estimated total municipal and industrial water use in the Uintah Basin was 24,426.6 ac-ft/yr (UDNR 2000c).

Groundwater quality in the Uinta Basin decreases with increased travel distance from recharge locations and with increasing depth. Concentrations of TDS in the basin show a range that affects the potential use of the water. In many locations, the water is marginally useful or even unsuitable for domestic use or irrigation.

Protection of public drinking water sources, including wellhead protection and surface water source protection, is administered by the state (UDEQ 2012a).

3.4.3.2 Surface Water Resources

The Uinta Basin is bounded by the Uinta Mountains on the north and the Roan Plateau on the south. The basin is dissected by the deeply incised southward-flowing Green River, the largest tributary of the Colorado River. The Green River is joined by two major tributaries, the Duchesne and White Rivers, near Ouray, Utah (Figure 3.4.3-1). The combined flow of the White, Duchesne, and Green Rivers near Ouray averages about 5,900 cfs, based on records from 1965 to 1979 (Lindskov and Kimball 1982). About 4 million ac-ft of water per year enters the basin (via the Duchesne, Green, and White Rivers) and leaves (via the Green River) (Lindskov and Kimball 1984). Most of the flow is attributed to water entering the basin by the White and Green Rivers.

The Uinta Basin can be divided into the northern and southern Uinta Basin by using the Strawberry, Duchesne, and White Rivers in Utah and Colorado as a divide (Figure 3.4.3-1). The northern area includes two major drainages, the Strawberry and Duchesne, with a combined drainage area of 4,250 mi^2. The oil shale considered in the study area of this PEIS lies mostly in the southern Uinta Basin and in a small area in the southern part of the northern Uinta Basin within the Duchesne drainage.

Most of the tributaries of the Duchesne drainage begin on the south slope of the Uinta Mountains. Major tributaries to the Duchesne River include the Whiterocks River, Uinta River, Dry Gulch Creek, Lake Fork River, Rock Creek, North Fork and West Fork Duchesne Rivers, Red and Currant Creeks, and the Strawberry River. The Duchesne River flows to the east and joins the Green River near Ouray, Utah.

The average annual volume of precipitation on the northern Uinta Basin is estimated to be 4.87 million ac-ft on the basis of data from 1941 to 1970. The average annual transbasin inflow includes 3.03 million ac-ft in the Green River and 521,000 ac-ft in the White River. About 4.27 million ac-ft are consumed annually by evapotranspiration (Hood and Fields 1978), and 190,000 ac-ft/yr are exported to the southern Uinta Basin and Great Basin. The average outflow of the Green River from the northern Uinta Basin is about 3.95 million ac-ft/yr (Hood and Fields 1978).

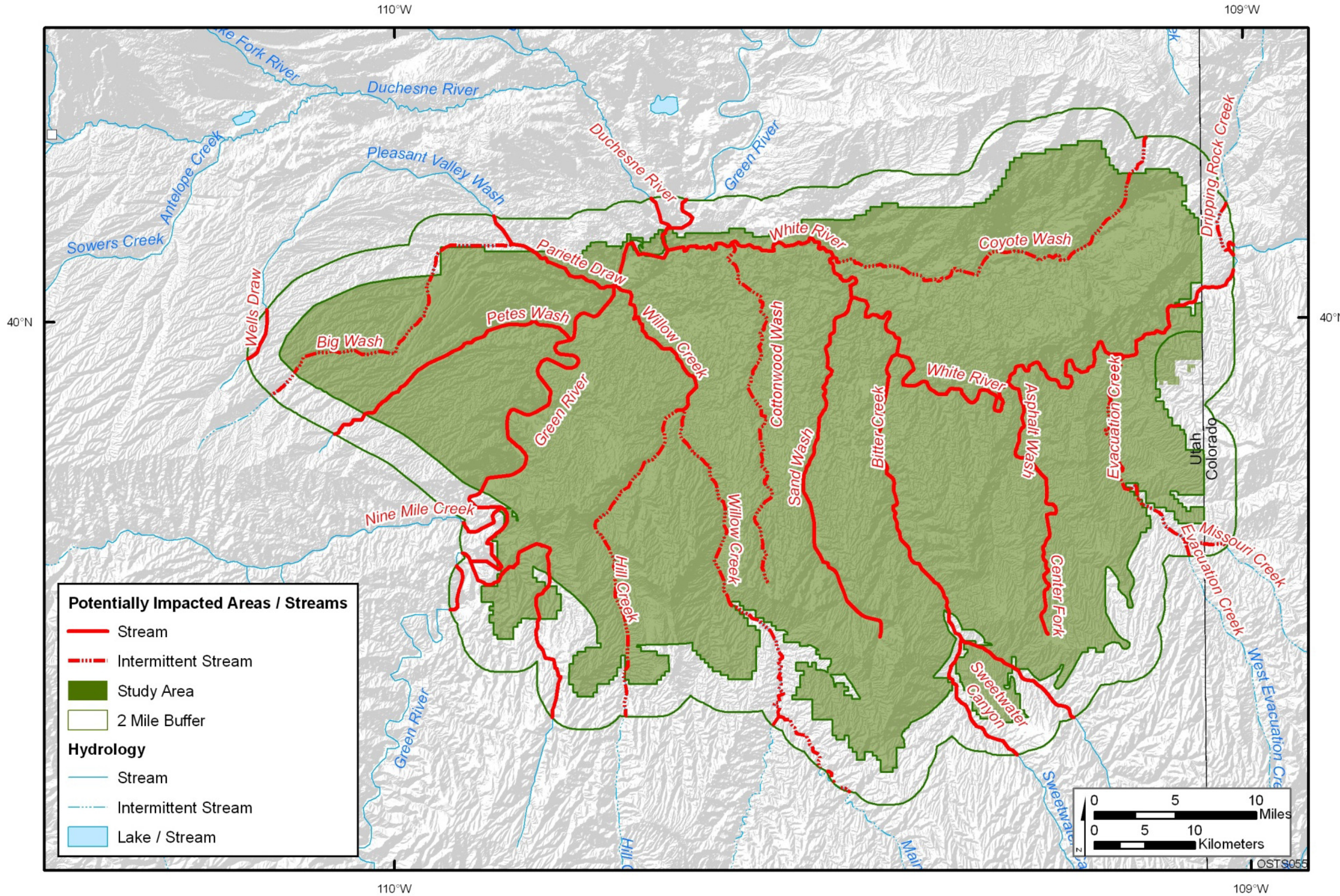

FIGURE 3.4.3-1 Major Rivers and Their Tributaries in the Uinta Basin

The southern Uinta Basin lies south of the Strawberry, Duchesne, and White Rivers in Utah and Colorado, draining an area about 4,900 mi^2. Most of the major streams on the southern Uinta Basin originate from the Roan Plateau and flow northward to the Duchesne and White Rivers (Price and Miller 1975). Major perennial and intermittent streams west of the Green River include the Pariette Draw, Petes Wash, Indian and Lake Canyons, and the Avintaquin, Antelope, Sowers, and Nine Mile Creeks. Streams east of the Green River include the Willow, Bitter, and Evacuation Creeks, and the Asphalt, Sand, and Coyote Washes.

The average annual volume of precipitation on the southern Uinta Basin is estimated to be 3.1 million ac-ft on the basis of data from 1941 to 1970. Another 80,000 ac-ft/yr are transported into the basin from the northern Uinta Basin. The estimated annual runoff from the southern Uinta Basin is 134,000 ac-ft (Price and Miller 1975; Hood and Fields 1978). The subbasins that may be developed to provide sustainable water supply are Evacuation, Willow, Nine Mile, Range, and Avintaquin Creek, with a total estimated mean annual runoff of 55,000 ac-ft/yr (Price and Miller 1975).

The climate of most of the Uinta Basin below an elevation about 8,000 ft is arid to semiarid. Average annual precipitation ranges from less than 8 in. near the bottom of the basin at altitudes below 5,000 ft to 26 in. in the western part of the Roan Plateau. Most of the precipitation is from snow in the winter and rainstorms in the late summer (Price and Miller 1975; Hood and Fields 1978; Lindskov and Kimball 1982).

The streamflow in the basin is extremely variable. Annual runoff varies from year to year and over periods of months, weeks, and days (Lindskov and Kimball 1984). Streams are typically perennial in the higher altitudes of the mountains and plateaus. They become intermittent and ephemeral in areas where annual precipitation is less than 10 in. and evapotranspiration is high (Lindskov and Kimball 1984). Evapotranspiration is estimated to be 94 to 98% of the precipitation in the basin (Price and Miller 1975; Lindskov and Kimball 1982). High streamflow occurs during snowmelt from March to June and during rainstorm activities in July, August, and September. The flows in the Green, Duchesne, and White Rivers are moderated by reservoirs built along the rivers or their tributaries.

The Duchesne River and its tributaries have been extensively affected by water development projects that supply water to the Wasatch Front. Construction of a system of transbasin tunnels, canals, and reservoirs began in 1915. The Duchesne River is currently undergoing four separate federal water projects as part of the Central Utah Project (BOR 2006). Flow of the Duchesne River has been reduced, and the river channel has been substantially changed in the last 50 years. The daily average streamflow measured near Randlett is 634 cfs (USGS 2006a). The minimum and maximum daily mean flows were 13 cfs and 7,000 cfs, respectively, based on 62 years of record (USGS 2006a). The maximum recorded peak discharge was 11,500 cfs. The USFWS (Modde and Keleher 2003) recommended a minimum flow of 115 cfs in the lower river between March 1 and June 30 and 50 to 115 cfs for the remainder of the year for endangered fish needs.

Dissolved salt in the rivers is a major concern in the Uinta Basin. The salts originate from marine and lacustrine sedimentary rocks and their derived soils that have high salt content.

Surface runoff, irrigation return flow, saline groundwater discharges, and evapotranspiration are the major causes of the elevated TDS concentrations in the surface water (Price and Miller 1975). The concentrations of dissolved salt in streams generally are low near headwater areas, but increase dramatically near the lower reaches of the streams. This is magnified during low-flow periods. For major rivers such as the Green, White, and Duchesne Rivers, the concentrations of dissolved salts are moderated by reservoirs. Recorded concentrations in the Green River generally are less than 1,000 mg/L throughout the year. During low flow in the White River, the TDS concentration is about 1,000 mg/L. The concentrations in the lower reach of the Duchesne River, however, commonly exceed 1,000 mg/L and occasionally exceed 2,000 mg/L during late irrigation and low-flow periods (Price and Miller 1975; Lindskov and Kimball 1984; UDEQ 2006).

Agricultural irrigation accounts for the largest use of water in the Uinta Basin, almost all of which is obtained from streams (Price and Miller 1975; Hood and Fields 1978). Irrigation water is applied mainly to lands that support the livestock and dairy industry.

3.4.4 Green River Basin and Washakie Basin

3.4.4.1 Groundwater Resources

Section 3.2.3 contains a description of the geological setting of both the Green River and Washakie Basins. Hydrogeological data for the basins are available in Mason and Miller (2004). Unconsolidated alluvial aquifers along major drainages generally have poor water quality. Alluvial thicknesses range up to 50 ft, and some portion of the alluvium may be saturated. Mason and Miller (2004) assembled historical well-yield data from across the basins and describe yield as less than 1 gpm to about 30 gpm in alluvium. Samples collected and analyzed during their study were found to have high concentrations of at least one of the following: TDS, nitrate, chloride, fluoride, sulfate, arsenic, boron, manganese, molybdenum, selenium, and uranium. Overall, less than 25% of the sampled alluvial groundwater was suitable for domestic use, but most was suitable for livestock.

In the Bridger-Washakie Formation, data from wells or springs were sparse. Samples represented a range of water types, and many were high in one or more water quality parameter such as sulfate, TDS, manganese, pH, boron, iron, or uranium. The samples varied in their suitability for domestic, livestock, or irrigation uses. The potential for groundwater development in these formations is not well known but probably poor. Well yields were not provided. The highest spring flow value presented was only 2.25 gpm.

In the Green River Formation, the water quality varies among the various formation members, but is mainly dependent on well depth and distance from groundwater recharge areas.

Data summarized by Mason and Miller (2004) for the Laney Member in the Green River Basin suggest well yields from 1 to 75 gpm. Information for the Washakie Basin suggests that well yields in the Washakie range up to 200 gpm, with TDS concentrations from 500 to

900 mg/L. Mason and Miller (2004) summarized water quality data for wells completed in the Laney Member in both basins. Half the samples were sodium-sulfate type; the remaining ones were mixed. The water quality of the samples was generally marginal to poor because of sulfate and TDS, which ranged from 311 to 53,700 mg/L, with a median of 2,080 mg/L. TDS concentrations increased with well depth and were significantly increased for wells more than 1,000 ft deep. Spring sampling showed a median TDS concentration of 2,200 mg/L. Some water well or spring samples were high in fluoride, boron, or manganese.

A small number of samples were reviewed or collected by Mason and Miller (2004) from the Wilkins Peak Member of the Green River Formation. These were all from recharge locations within the Green River Basin. The samples were of mixed water chemistry, with high sulfate and TDS concentrations. The water was suitable for livestock watering, and some of the samples represented water acceptable for irrigation or domestic use. Mason and Miller (2004) summarized prior studies on the Wilkins Peak water quality, in which the water was of very poor quality, and suggested that the water quality worsens rapidly with distance traveled. Well yields in the Wilkins Peak were reported to be less than 30 gpm.

To address the Tipton Shale Member, Mason and Miller (2004) reviewed and collected groundwater sample data. Water chemistry was found to be either sodium bicarbonate or mixed. The samples had TDS levels that made them marginally suitable for domestic use, but they were acceptable for livestock watering. However, a few of the samples were high in boron or fluoride. These samples were from wells in the Green River Basin, which were in use for livestock watering or other purposes; they were, therefore, not of poor quality. A review of historical reports on other water samples in the Green River Basin found groundwater in the Tipton Shale to be of good quality in portions of the Green River Basin, but poorer in other parts of the basin. Yields from nine wells in the Tipton Shale ranged from 10 to 170 gpm. The potential for groundwater development in the Washakie Basin is considered to be low.

No data are available for the Luman Tongue of the Green River Formation. The aquifer can probably produce enough groundwater for livestock or domestic use, provided the well is close to a recharge area (Mason and Miller 2004).

A review of wells completed in the Wasatch showed yields from less than 1 to 1,300 gpm, with most less than 500 gpm (Mason and Miller 2004). Samples from 84 Wasatch water wells and springs were completed by Mason and Miller (2004). The water type ranged from sodium bicarbonate to sodium sulfate to mixed water types. Concentrations of TDS, sulfate, and fluoride were generally high, and boron was high in some locations. Of 84 samples from water wells and springs, many were at least marginally acceptable for domestic use; almost all were acceptable for livestock, but only half were suitable for irrigation use. Fifty produced water samples had TDS concentrations ranging from 1,050 to 130,000 mg/L, with a median of 13,000 mg/L. Most were sodium chloride type. Deeper samples had higher TDS concentrations, with wells more than 2,000 ft deep generally unsuitable for domestic, irrigation, or livestock use.

Wyoming classifies its aquifers according to standards designed to protect groundwater of a given classification from anthropogenic degradation, so that the water quality is suitable for its intended use or potential future use (WDEQ 2005). Three categories have been defined on the basis of ionic concentrations and other water quality parameters, including TDS. The Class I aquifers are those for domestic use and have TDS concentrations up to 500 mg/L. The Class II aquifers are for agricultural use and have TDS concentrations from 500 to 2,000 mg/L. The Class III aquifers are for livestock watering and have TDS concentrations from 2,000 to 5,000 mg/L. Class IV aquifers have TDS concentrations above 5,000 mg/L and may be used by industry.

Recharge to the aquifers in Sweetwater County occurs as infiltration in aquifer outcrop areas (including snowmelt infiltration at high elevations), losing streams, and even irrigation water infiltration (Mason and Miller 2004). Overall areal recharge is less than 0.5 in./yr. The bulk of groundwater discharge out of the county takes place as bedrock aquifer flow and alluvial underflow, with minor amounts of well withdrawals (Mason and Miller 2004).

The Green River and Washakie Basins are sparsely populated. In Sweetwater County, Wyoming, which contains most of the basins, the estimated mean daily water use in 2000 was 170 million gpd (Mason and Miller 2004). The largest water use is irrigation, at an estimated mean daily rate of 92 million gpd, of which 90% was surface water. Groundwater, though relied on as a resource to a much smaller degree than surface water, is the sole source of water in many areas. The second largest water use in Sweetwater County was mining (41 million gpd), for which essentially all water was saline groundwater. The predominant mining water use was for trona mining and oil and gas production (Mason and Miller 2004).

Population centers in the Wyoming basins are located in the Green River Basin, with the cities of Rock Springs and Green River composing more than 80% of the Sweetwater County population (Mason and Miller 2004). These cities, as well as the town of Granger, rely on surface water for municipal supply, with Granger along Blacks Fork, Rock Springs at the confluence of Bitter Creek and Killpecker Creek, and Green River along the Green River itself.

Groundwater use by irrigation, public supply, industry, and domestic wells is essentially negligible (Mason and Miller 2004). Mining operations have constituted the only significant use of groundwater in Sweetwater County.

Groundwater quality in the basins decreases in quality with increased travel distance from recharge locations and with increasing depth (Mason and Miller 2004). TDS concentrations are moderately saline to briny in aquifers a few thousand feet deep, but locally even shallow groundwater can have moderate salinity. In Sweetwater County, which contains most of the Green River and Washakie Basins' oil shale, shallow groundwater is available in most places (Mason and Miller 2004). However, high TDS concentrations in many locations cause the water to be marginally useful or even unsuitable for domestic use or irrigation. Water of livestock-watering quality is generally available in the county.

In addition to having high TDS concentrations, groundwater from some aquifers in Sweetwater County exceeds EPA drinking water standards for sulfate, fluoride, boron, iron, and manganese (Mason and Miller 2004).

Water quality in alluvial aquifers in Sweetwater County is generally poor because of high TDS concentrations (Mason and Miller 2004). Tertiary bedrock aquifers, although of variable quality, have the most abundant groundwater in the Sweetwater County vicinity and are the most widely used (Mason and Miller 2004).

Protection of public drinking water sources, including wellhead protection and surface water source protection, is administered by the State (WDEQ 2012b).

3.4.4.2 Surface Water Resources

The Green River Basin in Wyoming is part of the Colorado River Basin. Major tributaries of the Green River in the basin include the New Fork, Hams Fork, Big Sandy, Blacks Fork, and Henry's Fork Rivers; and Bitter Creek (Figure 3.4.4-1).

Annual rainfall within the basin varies with altitude, ranging from less than 8 in. on the basin floor to more than 50 in. in the surrounding mountain ranges (Hahn and Jessen 2001). The Fontenelle and Flaming Gorge Reservoirs are two major reservoirs on the Green River. In addition, there are many smaller reservoirs constructed along the major tributaries of the Green River.

The streamflow pattern in the basin is highlighted by spring snowmelts, with high flow from April to July. The streamflow is also moderated by reservoirs built along the rivers. For the Green River below the Fontenelle Reservoir in Wyoming, the mean annual flow was 1,780 cfs for the 1965 to 1984 period. The minimum and maximum annual flows were 690 cfs and 2,780 cfs, respectively. Near the town of Green River, Wyoming, the mean, maximum, and minimum annual flows of the Green River were 1,800, 3,010, and 689 cfs, respectively (Peterson 1988).

The water quality of the streams near mountains is generally good but deteriorates as the streams flow across the basin. The degradation of the water quality is caused by both natural and man-made sources (Strohman 2000). The Green River drainage above Fontenelle Reservoir and the Green River itself above Flaming Gorge Reservoir contain less than 500 mg/L TDS. The water at the Flaming Gorge Reservoir has a median TDS concentration at or slightly above 500 mg/L. The water quality of many streams originating in the low areas is rated as fair to poor in the capacity to support nongame fish, or the water does not have the potential to support fish (Strohman 2000).

Agricultural irrigation is the largest use of surface water in the basin. The most common use of irrigation is in the growth of grass hay for harvest and pasture. The BOR reported that for the 1986 to 1990 period, irrigation depletions in Wyoming's Green River Basin averaged 399,000 ac-ft, or about 79% of total depletions. Livestock and domestic and municipal uses account for the other uses of the surface water in the basin (SWWRC 2001a).

The oil shale area in the Washakie Basin of Wyoming is drained by the tributaries of the Little Snake River. Alkali Creek and Vermillion Creek are two perennial rivers draining the

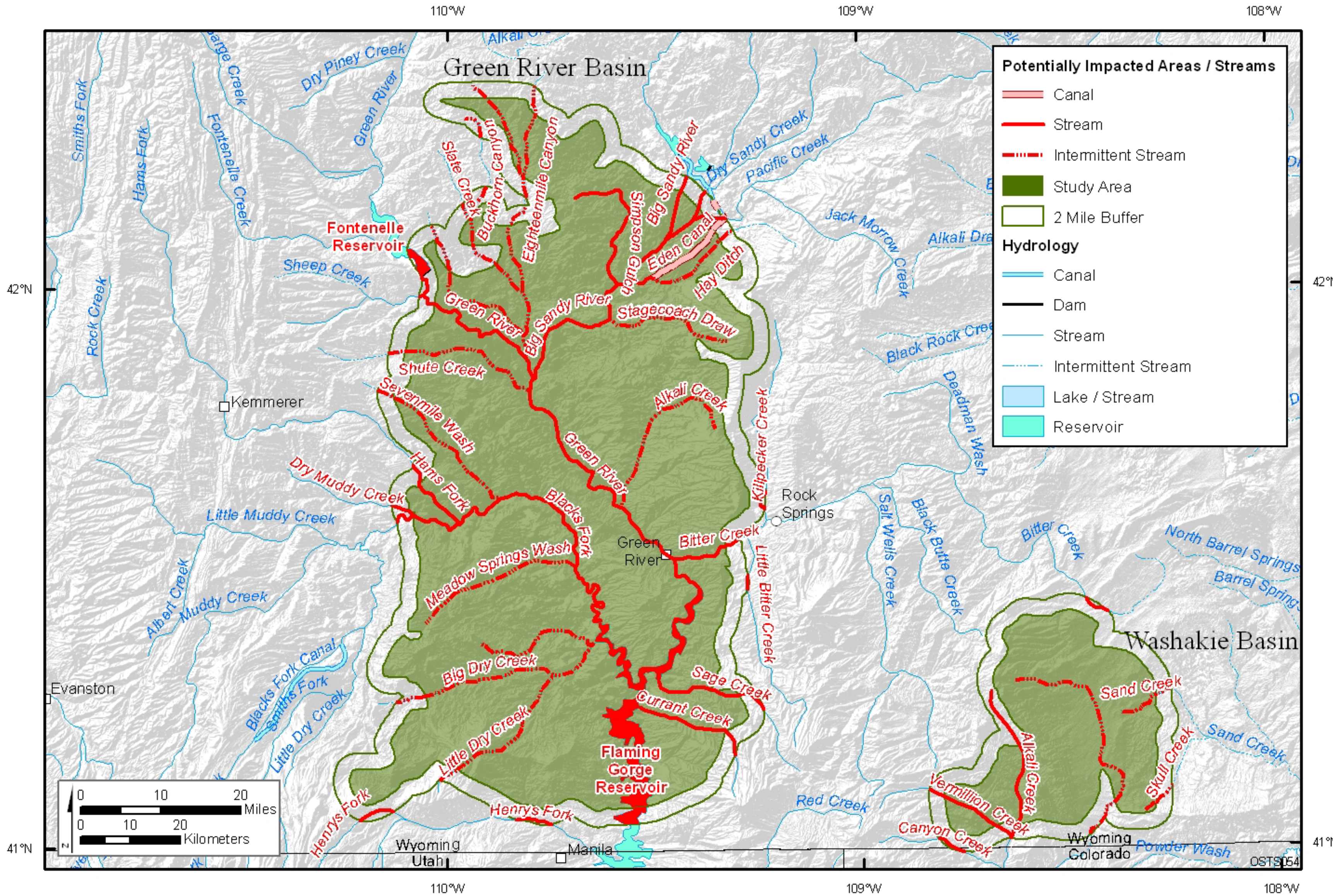

FIGURE 3.4.4-1 Major Rivers and Their Tributaries in the Green River and Washakie Basins

basin. Most of the other creeks in the basin, such as Sand Creek, Shell Creek, and Barrow Spring Draw, are ephemeral.

Annual precipitation varies with elevation, ranging from less than 10 in. near the bottom of the basin to more than 18 in. near the summit of Pine Mountain in the southwestern part of the basin. For most streams in the basin, high flow occurs during periods of snowmelt and rainstorms, and low flow occurs during the fall and early winter. Extended periods of no flow are common for ephemeral streams. Most ephemeral streams are also losing streams (Mason and Miller 2004).

3.4.5 Special Tar Sand Areas

3.4.5.1 Groundwater Resources

The BLM (1984b) compiled groundwater information for each STSA, including estimates of well yields, spring flows, and ranges of TDS values (Table 3.4.5-1). In cases where sufficient data are available, wide ranges of values are noted for each parameter. Water quality is affected by the geochemistry of the unconsolidated and bedrock aquifers. Groundwater quality is typically better from shallower sources.

Groundwater at or near the 11 STSAs is likely used for a combination of mining, stock watering, irrigation, domestic, municipal, and industrial uses. Local withdrawals at each STSA are dependent upon mining activities, population density, and agricultural land use.

3.4.5.2 Surface Water Resources

Precipitation varies across the STSAs with elevation. Higher-elevation STSAs, such as Argyle Canyon and Sunnyside, receive 30 or more in./yr of precipitation (BLM 1984b). Most of the STSAs, however, receive less than 8 in./yr. At San Rafael, annual precipitation is less than 6 in.

Except for San Rafael Swell, Tar Sand Triangle, Circle Cliffs, and White Canyon, most of the STSAs are located in the Uinta Basin. The hydrology of the Uinta Basin is described in Section 3.4.3.2. Figure 3.4.5-1 shows the streams and intermittent streams draining the STSAs.

The STSAs in the northern Uinta Basin that are drained by perennial and intermittent streams include Raven Ridge and Asphalt Ridge. The Asphalt Ridge STSA is crossed by the Twelve Mile Wash, which flows south and discharges into the Green River. The Raven Ridge STSA is crossed by the Powder Springs Wash, which flows westward into the Green River (Blackett 1996). Both the Twelve Mile Wash and the Powder Springs Wash are intermittent streams.

TABLE 3.4.5-1 Groundwater Data within or near STSAs

STSA	Water Source	Well Yield or Spring Flow (gpm)	TDS (mg/L)	Formation(s)
Argyle Canyon and Sunnyside	Wells and springs	<1–350	190–67,800	Alluvium, Green River, Uinta, and others
Asphalt Ridge	Wells	0.1–503	149–2,420	Duchesne River, and others
Asphalt Ridge	Springs	36–83,250	69–742	From Chinle Formation, possibly others
Circle Cliffs	Wells, including mine dewatering	NA[a]	188–8,510	NA
Hill Creek and P.R. Spring	Springs	Up to 50, though most are less than 10	297–6,110	Alluvium, Bird's Nest Aquifer of the Parachute Creek Member and Douglas Creek Member of the Green River Formation
Pariette	Wells	3–60	116–4,480	Uinta
Raven Ridge	Wells	0.1–200	221–118,000	Uinta, Green River, Wasatch, and others
San Rafael Swell	Wells	2.8–200	NA	Navajo, Moenkopi, and others
San Rafael Swell	Springs	<1–200	NA	Navajo, Moenkopi, and others
Tar Sand Triangle and White Canyon	Wells	Up to 70, most are <50	318–85,500	Navajo, Wingate, and Coconino
Tar Sand Triangle and White Canyon	Springs	360–450	179–6,530 (most are <2,400)	Navajo, Wingate, and Coconino

[a] NA = data not available.

Source: BLM (1984b).

The STSAs in the southern Uinta Basin that are drained by perennial and intermittent streams within a distance of 0.25 mi include the P.R. Spring and Hill Creek STSAs east of the Green River, and the Pariette Draw, Sunnyside, and Argyle Canyon STSAs west of the Green River (Figure 3.4.5-1).

Pariette Draw and its tributaries drain the area near the Pariette STSA. Pariette Draw is a perennial stream, discharging to the Green River.

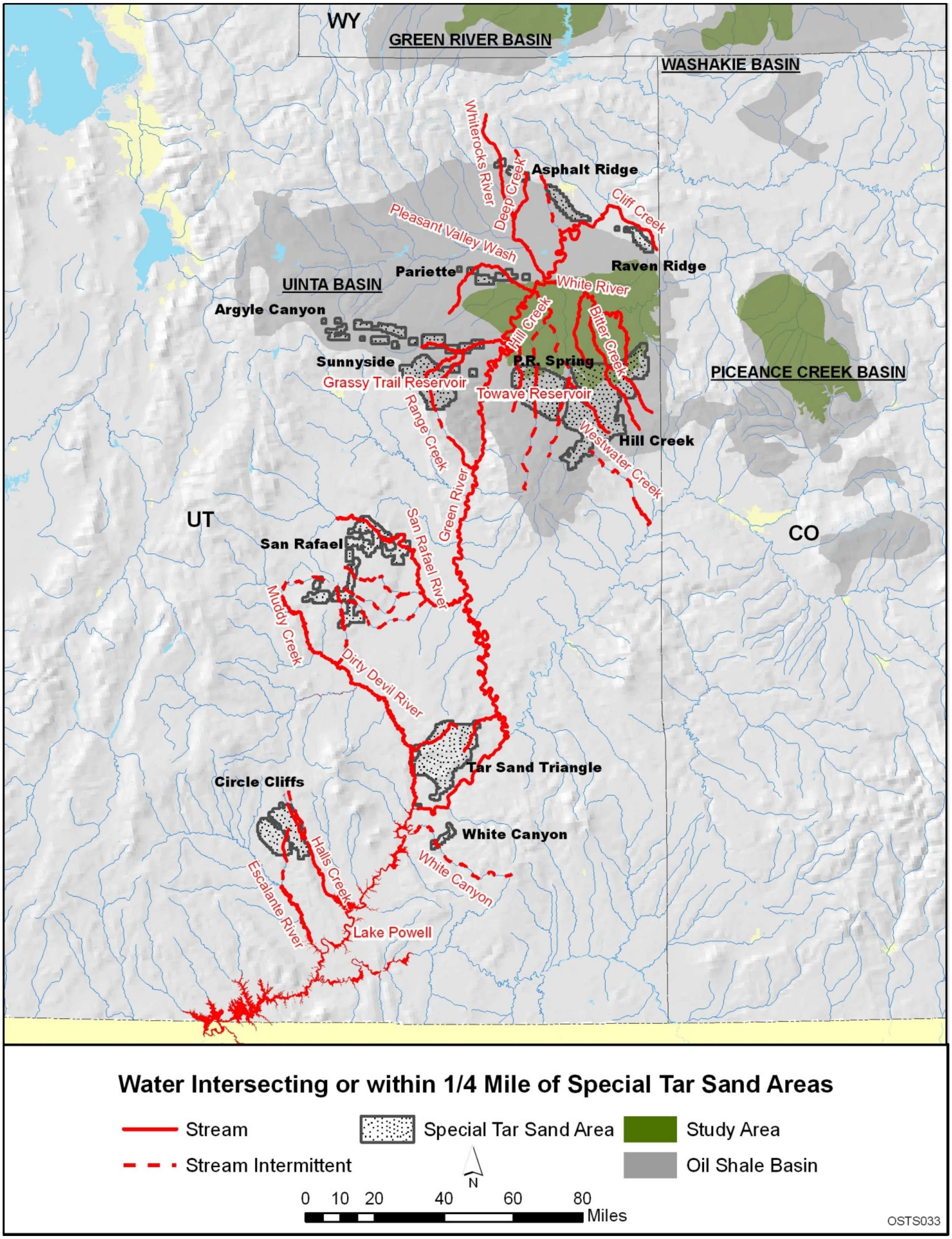

FIGURE 3.4.5-1 Green River and Dirty Devil River Basins Drainage Map

The P.R. Spring and Hill Creek STSAs are incised by intermittent and perennial streams, forming a dendritic drainage pattern. The P.R. Spring STSA is drained by Bitter Creek, Sand Wash, and Willow Creek and their tributaries. The Hill Creek STSA is drained by the Hill Creek and Tabyago Canyon and their tributaries (Blackett 1996). The Sunnyside STSA is dissected by tributaries of Dry Creek and Cotton Wood Canyon, and the upper reach of Range Creek. Dry Creek and Cotton Wood Canyon are two major tributaries of Nine Mile Creek. The upper reach of Range Creek is an intermittent stream. Both Nine Mile Creek and Range Creek discharge to the Green River (Blackett 1996).

The Argyle Canyon STSA is exposed along the valley of Argyle Creek that flows eastward to join Minnie Maude Creek and Nine-Mile Creek, forming the main stem of Nine-Mile Creek.

The San Rafael Swell STSA is primarily drained by the San Rafael River and its tributaries in a desert environment. The river is part of the West Colorado drainage, draining to the Green River. The main stem of the San Rafael River is a perennial river, while most of the tributaries that cross the STSA are intermittent streams. Based on 68 years of record, the annual runoff of the San Rafael River near Green River, Utah, is 374 cfs (USGS Gage 09328500), with a minimum and maximum flow of 1.2 cfs and 2,760 cfs, respectively (USGS 2006b).

The Tar Sand Triangle STSA is in the lowlands within the lower Dirty Devil River Basin, Utah (Figure 3.4.5-1). The Green and Colorado Rivers flow on the east side of the deposit, and the Dirty Devil River on the west. The Dirty Devil River is a tributary of the Colorado River and is formed by the confluence of Muddy Creek and the Fremont River. From Hanksville downstream, the Dirty Devil River has no perennial tributaries (Hood and Danielson 1981). Based on 49 years of record, the annual runoff of the Dirty Devil River near Hanksville, Utah (USGS Gage 09333500), is 98.6 cfs, with a minimum and maximum flow of 0 cfs and 975 cfs, respectively (USGS 2006c). The Dirty Devil River joins the Colorado River at the Lake Powell Reservoir.

About 96% of the precipitation in the lower Dirty Devil River Basin is consumed by evapotranspiration. The long-term average annual inflow and outflow of the Dirty Devil River is estimated to be 1.6 million ac-ft (Hood and Danielson 1981). High streamflow is expected in spring and occasionally during summer rainstorms. The water quality of the Dirty Devil River near the Colorado River is slightly saline.

No perennial streams are present in the Circle Cliffs STSA, which is crossed by several intermittent streams of Hall Creek and the Escalante River. Both Hall Creek and the Escalante River are tributaries of the Colorado River. The main stem of the Escalante River is located about 6 mi southwest of the deposit (Glassett and Glassett 1976).

The White Canyon STSA is crossed by White Canyon, an intermittent stream discharging to the Colorado River. Surface water resources in this STSA are very limited. Lake Powell (Reservoir) on the Colorado River is located more than 7 mi west of the area.

The BLM (1984b) compiled information on surface water flow rates, water quality, and water uses for rivers and streams near the 11 STSAs. Average flows at various stations along the major rivers (Duchesne, White, Green, and Colorado) ranged from hundreds of thousands to millions of ac-ft/yr. Smaller rivers (Strawberry, Price, Escalante, and Dirty Devil) had flows in the tens of thousands of ac-ft/yr. Creeks typically had flows in the thousands of ac-ft/yr. Most TDS concentrations for the surface waters ranged from about 500 to 7,000 mg/L. Bitter Creek, near the Hill Creek and P.R. Spring STSAs, was the sole location above this range; its TDS concentrations ranged to a high of 15,500 mg/L.

At the Argyle Canyon, Sunnyside, and Asphalt Ridge STSAs, surface water is used for irrigation, livestock, domestic, municipal, and industrial supplies (BLM 1984b). At the Circle Cliffs STSA, surface water is used for irrigation and livestock. Water at the Hill Creek and P.R. Spring STSAs is used for irrigation, gilsonite mining, livestock, and oil development. Minimal surface water use takes place at the Pariette and Raven Ridge STSAs. At the San Rafael STSA, surface water, including reservoir water, is used for irrigation and for the Huntington Power Plant. At the Tar Sand Triangle and White Canyon STSAs, water is used for livestock, mining, irrigation, and domestic supplies.

3.5 AIR QUALITY AND CLIMATE

3.5.1 Climate

3.5.1.1 Meteorology

Because of wide variations in elevation, topographic features, and latitude within the study area, meteorological conditions vary considerably among specific locations. Other than a highland climate in mountainous areas, the study areas have a semiarid mid-continental climate characterized by abundant sunshine, low humidity, low precipitation, and cold, snowy winters. Strong, outgoing terrestrial radiation provides cool nights. In midwinter, air temperatures are often low, but strong solar radiation and dry air combine to provide generally pleasant conditions.

The local climate is strongly influenced by microclimatic features such as slope, aspect, and elevation. The local surface wind patterns and vertical temperature profiles are almost entirely dependent upon topography. Predominantly westerly winds provide additional moisture on the western mountain slopes, with drier conditions on the lee side (often referred to as “rain shadows”).

The predominant prevailing wind direction aloft over the region is from the west and southwest (the westerlies) as in most of the United States; however, surface air movement patterns are greatly modified by local terrain and ground cover. Wind roses (which graphically display the distribution of wind speed and direction classifications from which the winds originate) at the 33-ft level for selected meteorological stations around the study area for the

5-year period (2006–2010) are shown in Figure 3.5.1-1 (NCDC 2011a). As shown in the figure, some locations display westerly winds, but prevailing wind directions are different from site to site (most obviously for Grand Junction, Colorado, located just southwest of the Book Cliffs). Average wind speeds range from 5 to 7 mph in Colorado and Utah, with the highest speed of over 11 mph measured at the Rock Springs, Wyoming, airport, which is situated on a mesa at an elevation of over 6,700 ft. Stations located in the valleys typically experience nocturnal drainage flow of denser cold air at higher elevations into the valley floor. This condition causes poor dispersion and stagnation, which tend to trap air pollutants within the valley. A higher occurrence of low wind speeds or calm conditions is typically measured at these sites. The Meeker, Moab, and Vernal surface stations show very high occurrences of stagnant conditions (i.e., calm periods occur about one-third of the time).

Temperatures in the region vary widely with elevation, latitude, season, and time of day. Historical annual average temperatures measured at selected meteorological stations in and around the study area range from 36°F in Big Piney, Wyoming (just east of the Wyoming Range

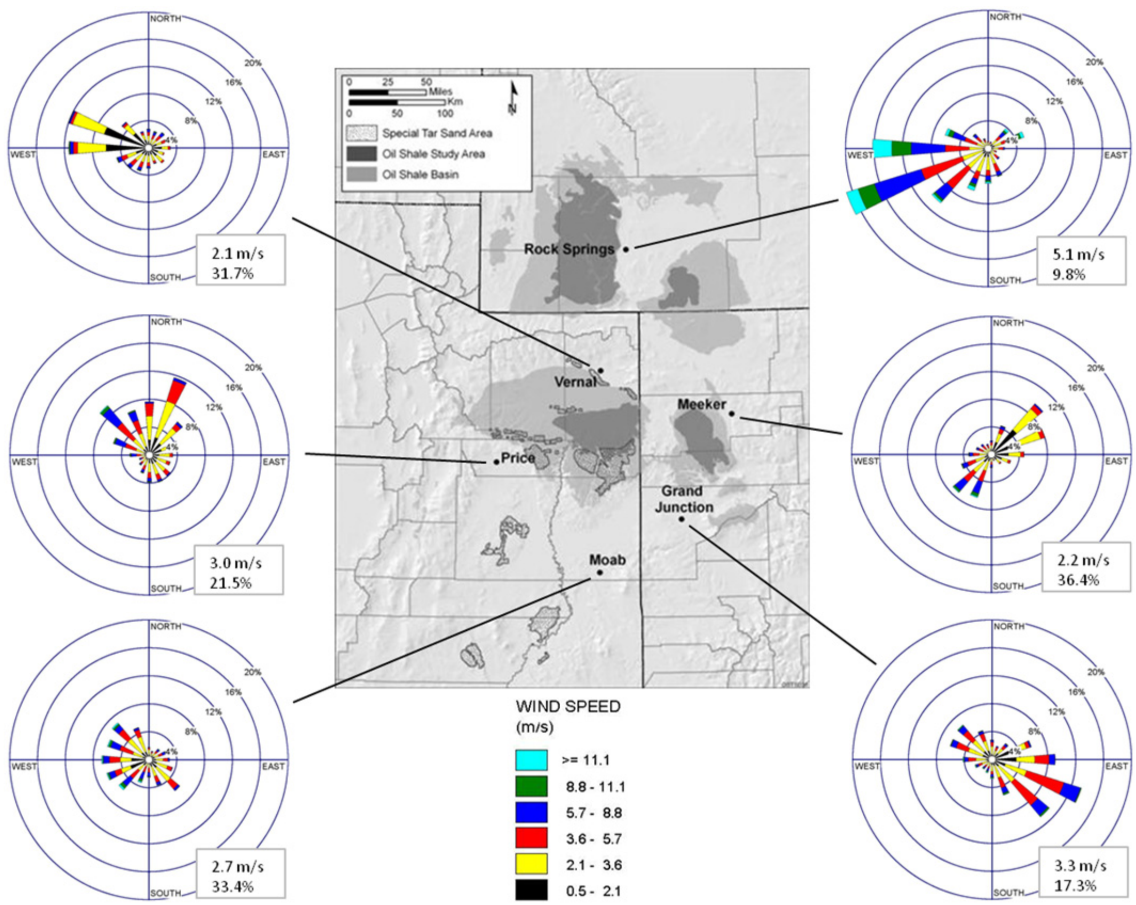

FIGURE 3.5.1-1 Wind Roses at the 33-ft Level for Selected Meteorological Stations around the Study Area, 2006–2010 (Source: NCDC 2011a) (Note that the first and second values in the lower-right corner of each wind rose denote the average wind speed [m/s] and calm wind frequency [%], respectively.)

at an elevation of 6,800 ft), to 54°F in Hanksville, Utah (in a desert setting), as presented in Table 3.5.1-1 (WRCC 2011). Typically, January is the coldest month, ranging from −5°F to 16°F, and July is the warmest month, ranging from 80°F to 98°F.

Although limited monitoring occurs mostly in lower elevation towns, the average precipitation around the study area ranges from around 6 in. in Hanksville, Utah, to about 17 in. in Meeker, Colorado (WRCC 2011). Much higher values are expected in mountainous locations. In general, precipitation is greatest in spring and fall, and low in winter months around the study area. Snowfall is quite variable by location (ranging on average from about 7 in. in Hanksville, Utah, to more than 71 in. in Meeker, Colorado), with the snowiest months being December through February. In general, snowfall tends to increase with increasing latitude and elevation, while precipitation has a weak relationship with respect to latitude and elevation.

Complex terrain typically disrupts the mesocyclones associated with tornado-producing thunderstorms; thus, tornadoes are less frequent and destructive in this region. For example, tornado frequencies per area in counties within the oil shale study area in Colorado are about one-fiftieth of those in the rest of the state. From January 1950 to April 2011, 75 tornadoes were reported in the counties within the study area, with 2,561 reported for Colorado, Utah, and Wyoming combined (NCDC 2011b). Most tornadoes that occurred in the study area were relatively weak, mostly F0 or F1 on the Fujita tornado scale[9] (except for three F2s and one F3); statewide, most (71%) tornadoes were reported in Colorado, with categories F0, F1, and F2 and above, each accounting for about 63, 29, and 7%, respectively, of the combined states' total.

3.5.1.2 Global Climate Change

Climate is both a driving force and a limiting factor for biological, ecological, and hydrological processes; it has great potential to influence resource management. Climate change is a phenomenon that could alter natural resource and ecologic conditions on spatial and temporal scales that have not yet been experienced by humans.

Ongoing scientific research has identified the potential impacts of man-made greenhouse gas (GHG) emissions, changes in biological carbon sequestration, and other changes due to land management activities on the global climate. Through complex interactions on a regional and global scale, these changes cause a net warming of the atmosphere, primarily by decreasing the amount of heat energy the earth radiates back into space. Although natural GHG levels have varied for millennia, recent industrialization and burning fossil carbon sources have caused carbon dioxide equivalent (CO_2e) concentrations to increase dramatically and are likely to contribute to overall global climatic changes. The Intergovernmental Panel on Climate Change (IPCC) has stated, "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic [man-made] GHG concentrations" (IPCC 2007). The general consensus is that as atmospheric concentrations of GHGs continue to rise, average global temperatures and sea levels will rise, precipitation

9 Fujita scale F0, F1, F2, and F3 through F5 tornadoes are classified with wind speeds of 40 to 72 mph, 73 to 112 mph, 113 to 157 mph, 158 to 206 mph, and up to 261 to 318 mph, respectively.

TABLE 3.5.1-1 Temperature and Precipitation Summaries at Selected Meteorological Stations in and around the Study Area

Station	State	County	Temperature (°F)[a] Average Monthly Minimum	Temperature (°F)[a] Average Monthly Maximum	Temperature (°F)[a] Mean[b]	Precipitation (in.) Total Water Equivalent	Precipitation (in.) Snowfall	Period of Record
Grand Junction	CO	Mesa	15.9	92.9	51.8	8.70	21.6	1/1/1900 – 12/31/2010
Meeker	CO	Rio Blanco	6.2	85.8	45.4	16.59	71.1	1/1/1893 – 12/31/2010
Rifle	CO	Garfield	9.3	90.2	47.8	11.58	38.5	9/9/1910 – 11/30/2007
Hanksville	UT	Wayne	10.9	98.2	53.5	5.69	7.1	3/1/1910 – 12/31/2010
Price	UT	Carbon	13.4	90.0	50.0	9.28	18.3	9/1/1968 – 12/31/2010
Vernal	UT	Uintah	5.0	89.2	46.2	8.43	18.5	11/1/1894 – 12/31/2010
Big Piney	WY	Sublette	–5.3	80.0	35.8	7.46	28.6	8/1/1948 – 11/30/2001
Rawlins	WY	Carbon	12.6	83.8	44.1	9.03	51.9	3/6/1951 – 5/31/2008
Rock Springs	WY	Sweetwater	11.2	83.4	41.8	8.69	43.6	8/1/1948 – 12/31/2010

[a] "Average Monthly Minimum" denotes the monthly average of daily minimum values during the period of record, which normally occurs in January. "Average Monthly Maximum" denotes the monthly average of daily maximum values during the period of record, which normally occurs in July.

[b] NCDC 1971 to 2000 monthly normals.

Source: WRCC (2011).

patterns will change, and climatic trends will change and influence the earth's natural resources in a variety of ways.

There are uncertainties associated with the science of climate change, but this does not imply that scientists do not have confidence in many aspects of climate change science. According to the EPA, some aspects of the science are "known with virtual certainty because they are based on well-known physical laws and documented trends" (EPA 2011a).

Secretarial Order 3289 directs the Department of the Interior's component bureaus, including the BLM, to address the impacts of climate change on America's water, land, and other resources (Secretary of the Interior 2009). Management decisions made in the context of climate change impacts must be informed by science and require that scientists work with managers who are confronting this issue to evaluate impacts through the NEPA process. CEQ is crafting guidance on addressing climate change in NEPA documents for federal agencies, which will eventually assist the BLM (and other DOI agencies) in addressing climate change.

3.5.1.2.1 Current GHG Conditions. GHGs are compounds in the atmosphere that absorb infrared radiation and re-radiate a portion of that back toward the earth's surface, thus trapping heat and warming the earth's atmosphere. The most important naturally occurring GHG compounds are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and water vapor. CO_2, CH_4, and N_2O are produced naturally by respiration and other physiological processes of plants, animals, and microorganisms; by decomposition of organic matter; by volcanic and geothermal activity; by naturally occurring wildfires; and by natural chemical reactions in soil and water. Ozone is not released directly by natural sources, but forms during complex photochemical reactions in the atmosphere among volatile organic compounds (VOCs) and nitrogen oxides in the presence of ultraviolet radiation (sunlight). While water vapor is a strong GHG, its concentration in the atmosphere is primarily a result of, not a cause of, changes in surface and lower atmospheric temperature conditions.

Human activities contribute some water vapor to the atmosphere, but their contribution is infinitesimal compared with massive amounts of water that are naturally cycling through the atmosphere. Tropospheric O_3, which is a secondary pollutant, is short-lived, so O_3 does not have strong global climate change effects. Thus, water vapor and O_3 are not included in the GHG emission inventory.

Although naturally present in the atmosphere, concentrations of CO_2, CH_4, and N_2O also are affected by emissions from industrial processes, transportation technology, urban development, agricultural practices, and other human activity. In addition to these GHGs, three industrially generated GHGs also contribute to climate change: sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). CO_2 and CH_4 account for the most significant anthropogenic GHG emissions. For instance, the BLM-authorized activities accounting for the largest quantities of GHG emissions include fossil fuel development and production, large wildland fires, and activities using combustion engines (such as generators and vehicles). GHG emissions are often discussed in terms of CO_2e, which include multiple GHG pollutants and account for pollutant differences in contribution to global warming. A GHG's ability to contribute to global warming is based on its longevity in the atmosphere and its heat-trapping capacity. The EPA has assigned each GHG a global warming potential (GWP) that is used to calculate aggregate emissions. The CO_2e for each GHG is determined by multiplying the quantity of emissions by the GWP for that GHG. Total CO_2e emissions for all GHGs are then determined by adding the CO_2e emissions of each GHG. GWPs used for GHG emission calculations and reporting are 1 for CO_2, 21 for CH_4, and 310 for N_2O.

3.5.1.2.2 Global Climate Change Trends and Predictions. The IPCC and the National Oceanic and Atmospheric Administration (NOAA) estimated the following changes in global atmospheric concentrations of the most important GHGs (IPCC 2007; NOAA 2010):

- Atmospheric concentrations of CO_2 have risen from a pre-industrial background of 280 parts per million by volume (ppmv) to 386 ppmv in 2009;
- Atmospheric concentrations of CH_4 have risen from a pre-industrial background of about 0.70 ppmv to 1.79 ppmv in 2009; and
- Atmospheric concentrations of N_2O have risen from a pre-industrial background of 0.270 ppmv to 0.322 ppmv in 2009.

The IPCC has concluded that these changes in atmospheric composition are almost entirely the result of human activity, not the result of changes in natural processes that produce or remove these gases (IPCC 2007). The IPCC estimates that mean global surface temperatures increased by 0.74°C from 1906 to 2005 (IPCC 2007). In addition, the rate of warming averaged over the past 50 years is nearly twice that for the past 100 years.

Global and regional climatic changes have already been documented and will continue to occur due to GHG concentrations already present in the atmosphere and ongoing global emissions of GHGs. The global mean surface temperature has increased by approximately 1.5°F since 1900 (USGCRP 2009). Climate models indicate that average temperature changes are likely to be greater in the Northern Hemisphere. Northern latitudes (above 24° N) have exhibited temperature increases of nearly 2.1°F since 1900, with nearly a 1.8°F increase since 1970 alone. Without additional meteorological monitoring systems, it is difficult to determine the spatial and temporal variability and change of climatic conditions, but increasing concentrations of GHGs are likely to accelerate the rate of climate change.

Of 12 recent years (1995–2006), 11 rank among the 12 warmest years in the instrumental record of global surface temperature since 1880 (Figure 3.5.1-2). Global surface temperatures from 1906 to 2005 have increased approximately 0.74°C, with a range of 0.56°C to 0.92°C. The linear warming trend of global surface temperatures over the 50 years from 1956 to 2005 is 0.13°C per decade, which is nearly twice that for the 100 years from 1906 to 2005. Increases in sea level are consistent with warming.

In 2007, the IPCC indicated that by 2100 the global average surface temperature would increase by between 1.1°C and 6.4°C above 1980–1999 levels, depending on the assumptions

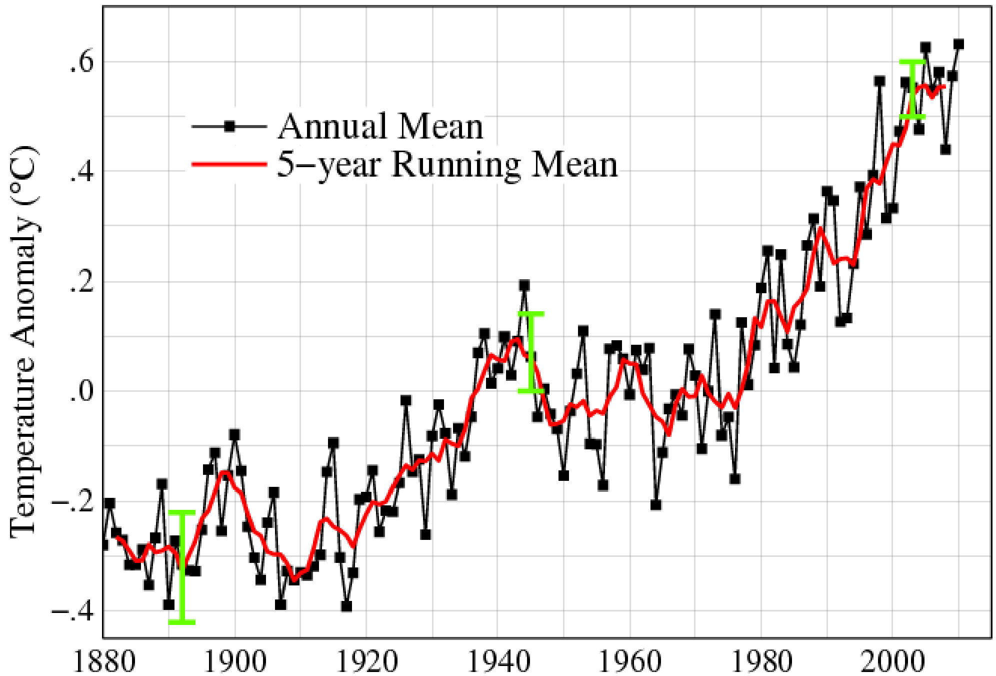

FIGURE 3.5.1-2 Global Mean Land-Ocean Temperature Index, 1880 to Present, with Base Period 1951–1980 (Source: GISS 2011)

made in the predictive model (IPCC 2007). The National Academy of Sciences has confirmed these findings but has indicated there are uncertainties regarding how climate change may affect different regions. Computer model predictions show that temperature increases will not be equally distributed but will likely be accentuated at higher latitudes. Warming during the winter is expected to be greater than during the summer, and increases in daily minimum temperatures are likely to be greater than increases in daily maximum temperatures. Increases in temperature would increase water vapor retention in the atmosphere and reduce soil moisture, increasing generalized drought conditions, while enhancing heavy storms. Although large-scale spatial shifts in precipitation distribution may occur, these changes are more uncertain and difficult to predict. In a warmer climate, the risk of more intense and longer heat waves will increase. Extremes of summer dryness and winter wetness will increase in most places, resulting in a greater risk of both droughts and floods; precipitation will concentrate in heavier rain events separated by longer dry periods (USGCRP 2009).

Climate change predictions are based on multiple modeling scenarios involving different sets of GHG emission assumptions. Emission assumptions are primarily based on determinations of global population growth, economic growth, fossil fuel development and use, and many other factors. The predictions described below are not based on implementation of GHG emission reduction programs, such as the Kyoto Protocol or EPA regulation of GHG emissions. For example, EPA recently began to regulate GHGs, and these regulations will decrease future U.S. GHG emissions through a variety of methods. EPA regulatory actions to date are as follows:

- Setting GHG emission standards for new light-duty vehicles;

- Requiring mandatory reporting of annual GHG emissions from many types of stationary sources responsible for the bulk of U.S. GHG emissions;

- Requiring air pollution control agencies to review GHG emissions when issuing air quality construction and operating permits for stationary sources with large quantities of GHG emissions; and

- Requiring identification and imposition of GHG emission reduction control technologies for large GHG emission sources before constructing new facilities or modifying or reconstructing existing facilities.

GHG emissions resulting from the above regulations have been included in past climate change modeling. Future global modeling and climate change predictions may include U.S. GHG emission reductions. Because of the long atmospheric lifetimes of GHGs, decreases in atmospheric GHG concentrations resulting from these regulations will occur over decades.

3.5.1.2.3 Climate Change Impacts on Regional Resources. Projected changes are likely to occur over several decades to a century. Therefore, many of the projected changes associated with climate change described below may not be measurable within the reasonably foreseeable future. However, research on climate change science is ongoing, and it is expected that regional research projects will only be finer in scale and will be more confident over time as the science advances. To the extent practicable, BLM management will review actions it authorizes and the impacts on or from climate change as the state of the science advances and as project authorization decisions are made.

Since global climate models poorly represent the complexity of the Rocky Mountain Region's topography, researchers are using "downscaling" and other techniques to study processes that matter to natural resource managers. Several research projects are under way to improve regional understanding—some use statistical "downscaling" methods, which adjust for the effects of elevation and the mountains on snowfall and temperature; other studies involve compiling, calibrating, and studying historical datasets; others involve enhanced climate modeling efforts to include finer spatial resolution that better represent the region's mountainous terrain.

This PEIS addresses potential environmental effects of land use allocations pertaining to potential oil shale and tar sands activities in Colorado, Utah, and Wyoming. Therefore, climate change trends are summarized for the Great Plains Region (as identified by the U.S. Global Change Research Program to include North Dakota, South Dakota, eastern Montana, Wyoming, eastern Colorado, Nebraska, Kansas, eastern New Mexico, Oklahoma, and central Texas) and the Southwest Region (which includes western Colorado, western New Mexico, western Texas, Utah, Arizona, Nevada, and California). Activities associated with oil shale and tar sands development, if any, would contribute to overall atmospheric GHG emissions; however, it is not possible at this time to predict either the specifics of those GHG emissions, or how they might result in specific climate change related impacts. See Chapter 4, Section 4.6.1.1, Climate Change, for more discussion on GHG emissions specific to oil shale and tar sands activities and climate change.

Much of the information summarized below is derived from the information represented by the color shadings on U.S. climate change maps (USGCRP 2009). Climate change predictions are within the given range represented on these maps and may not reach the maximum or minimum extents of the range. Past climate trends and future predictions for the region, including northwestern Colorado, southwestern Wyoming, and northeastern Utah, are as follows (IPCC 2007; Ebi et al. 2007; Saunders et al. 2008; EPA 2010; USGCRP 2009):

- The average temperature increased by 1 to 3°F from a 1961 to 1979 baseline average to the average temperature measured from 1993 to 2008. By 2059, the average temperature is predicted to increase by 3 to 5°F above the 1961 to 1979 baseline. Temperatures are expected to increase more in winter than in summer, more at night than during the day, and more in the mountains than at lower elevations.

- The annual number of days above 90°F and the frequency of extreme heat events will increase.

- Annual average precipitation increased between 5 and 15% between 1958 and 2008. Based on modeling using a high emissions scenario, predicted precipitation changes indicate increased precipitation in the winter (up to +20%) and substantial decreases in the spring (from 0% to –20%) and summer (0% to –15%). Fall precipitation is predicted to be within –5% to +5%.

- End-of-summer drought has increased during the last 50 years, and drought is expected to be more prevalent in the future.

- Annual runoff will decrease by 10 to 20% for the period 2041–2060, compared to period 1901–1970.

- Peak streamflow from melting snow is occurring earlier. In 2002, peak streamflow occurred up to 5 days earlier than during 1948. From 2080 to 2099, peak streamflow is predicted to occur 5 to 25 days earlier than during the 1951 to 1980 period.

- Very heavy precipitation occurred up to 16% more often between 1958 and 2007.

- Reduced winter snowpack and earlier snowmelt result in less water flowing into the Colorado River, less water available for downstream residential and agricultural users, and shorter ski seasons (unless additional snowmaking is used to prolong the season).

- In some areas of the Colorado River basin, declines in spring snowpack and streamflows may occur. Projections suggest continued warming, and summertime temperatures are greater than the annual average in some parts of the region.

- Water supplies are projected to become increasingly scarce, which may lead to conflicts among cities and agricultural users. Changes in stream morphology and aquatic habitat may occur because of changes in the magnitude, timing, and frequency of streamflows (Dunne and Leopold 1978).

- Wildfire activity is expected to increase because of rising temperatures, reductions in snowpack, and reductions in soil moisture.

- Earlier snowmelt means that peak stream flows occur earlier in the year, weeks before the peak needs of ranchers, farmers, recreationists, and others. In late summer, rivers, lakes, and reservoirs have lower flows and less capacity, which cause the following effects:
  - Less water availability for irrigating crops and watering animals;
  - Reduced crop and livestock productivity if additional irrigation is not available;
  - Increased water temperatures that adversely affect coldwater fish and reduce recreational fishing; and
  - Reduced mid- and late-summer stream flows that shorten tourism and recreation opportunities, such as whitewater rafting and boating.

- More frequent, more severe, and longer-lasting droughts are occurring and are expected to become more prevalent.

- Warmer and drier conditions will stress ecosystems and wildlife due to the following effects:
  - Shrinkage of coniferous forests and replacement with larger savannas and woodlands;
  - Greater pest infestations in pine forests, such as the pine beetle infestation in Colorado's lodgepole pine forests;
  - Contraction of aspen forests due to sudden aspen decline linked to reduced snowpack and drought; and
  - Grassland and rangeland expansion into previously forested areas.

- Land will have increased susceptibility to fire with more frequent, larger, and more intense fires.

- Geographic flora and fauna will shift to the north or to higher elevations. Some species may be at greater risk of extinction if they cannot successfully migrate or adapt.

- Longer growing seasons may increase productivity for some crops, decrease productivity for others, and increase agricultural pest populations, including weeds and insects.

- Warmer and drier conditions will adversely affect air quality due to the following effects:
  - Increased ambient concentrations of particulate matter because less-vegetated soils are more susceptible to wind erosion;
  - Increased ozone formation; and
  - Reduced visibility due to increased particulate matter and wildfire smoke.

- Climatic changes may have the following effects on human health:
  - Heavy precipitation increases frequency and severity of flooding and may contaminate water supplies;
  - Heat waves stress some individuals, particularly older adults and young children; and
  - Increased concentrations of ozone, particulate matter, and smoke stress some individuals, particularly those with asthma or other lung disease and those who exercise strenuously during poor air quality episodes.

It should be noted that uncertainty remains about the precise nature, timing, and severity of these effects in a given area. In addition, because the climate change models predict shifts in multiple climatic variables (e.g., the seasonal distribution, amount, and intensity of precipitation in addition to temperature regime), the precise relationship of these variables may profoundly influence the specific outcomes of climate change. It is also possible that some currently unknown future factors could result in different outcomes from those currently anticipated. Some of the predicted effects—particularly those involving shifts in plant and animal communities—may occur over a period of centuries due to the adaptability of the community and component species to changing conditions. Some community types may occur across an elevational or latitudinal range that represents a greater range of climatic conditions than the changes predicted by climate models. Existing communities may persist in conditions no longer favorable for their establishment. Therefore, elevational or latitudinal shifts in composition and structure may be discernible at the upper and lower margins of the community type while intermediate areas show less or no change.

3.5.2 Existing Emissions

Table 3.5.2-1 presents annual emission inventory data for criteria pollutants and volatile organic compounds (VOCs) for 2008 for counties within and around the study area in Colorado, Utah, and Wyoming (CDPHE 2012c; EPA 2012a; UDEQ 2012b). Source categories for emissions inventories are different from state to state because of different sources and assumptions.

In Colorado, the point source category accounted for most of the sulfur oxides (SO_X) emissions (about 91%) due to high levels of coal-fired power generation. The point source

TABLE 3.5.2-1 Annual Air Pollutant Emissions for Counties within and around the Study Area, 2008

		County Contains		Emission Rate (tons/yr)					
State	County	Oil Shale	Tar Sands	SO_x	NO_x	CO	VOC	PM_{10}	$PM_{2.5}$[a]
Colorado	Chaffee	No	No	24	827	9,521	12,044	1,852	724
	Delta	Yes	No	48	1,572	12,132	18,106	2,504	1,102
	Dolores	No	No	9	781	4,905	14,601	1,941	420
	Eagle	No	No	80	3,769	21,709	14,948	4,256	1,319
	Garfield	Yes[b]	No	279	13,546	35,464	55,727	6,338	2,341
	Grand	No	No	75	1,695	9,565	19,315	2,429	714
	Gunnison	No	No	44	1,421	13,470	22,306	2,544	1,110
	Jackson	No	No	5	509	4,527	20,996	608	226
	La Plata	No	No	68	10,454	30,009	24,153	4,416	1,458
	Lake	No	No	10	345	3,692	6,386	635	205
	Mesa	Yes	No	2,879	9,048	40,688	39,828	8,050	2,838
	Moffat	Yes	No	4,031	19,855	25,876	32,503	7,401	4,316
	Montezuma	No	No	71	2,077	16,605	23,923	3,062	1,057
	Montrose	No	No	1,358	3,665	19,533	21,220	5,823	2,316
	Pitkin	No	No	10	882	7,379	11,566	967	254
	Rio Blanco	Yes[b]	No	67	4,615	15,446	33,647	5,358	2,056
	Routt	No	No	2,582	8,732	10,777	26,362	4,856	1,449
	San Miguel	No	No	9	1,093	5,548	13,065	1,504	370
	Subtotal			11,649	84,886	286,846	410,696	64,544	24,273
Utah	Carbon	Yes[b]	Yes	5,672	5,733	11,811	17,006	1,931	460
	Daggett	Yes	No	3	946	4,284	14,341	327	108
	Duchesne	Yes[b]	Yes	20	3,096	12,784	24,689	2,877	684
	Emery	Yes	Yes	9,484	32,327	16,613	32,545	4,362	1,136
	Garfield	No	Yes	33	649	18,822	46,533	1,465	660
	Grand	Yes	Yes	129	3,749	19,816	37,309	3,277	780
	Kane	No	No	40	656	17,684	49,719	1,412	517
	Piute	No	No	10	114	7,340	13,470	326	93
	San Juan	No	Yes	47	1,521	24,839	66,066	2,962	993
	Sanpete	No	No	98	853	10,593	19,416	1,361	301

TABLE 3.5.2-1 (Cont.)

		County Contains		Emission Rate (tons/yr)					
State	County	Oil Shale	Tar Sands	SO_x	NO_x	CO	VOC	PM_{10}	$PM_{2.5}$[a]
Utah (Cont.)	Sevier	No	No	119	1,893	14,529	19,678	1,926	428
	Summit	Yes	No	239	5,380	19,646	20,894	2,912	546
	Uintah	Yes[b]	Yes	28	1,250	19,302	31,653	3,779	1,081
	Utah	Yes	Yes	406	11,645	80,904	33,132	10,184	2,094
	Wasatch	Yes	Yes	20	1,141	10,251	18,424	1,712	331
	Wayne	No	Yes	42	183	7,035	24,930	625	159
	Subtotal			16,389	71,135	296,252	469,805	41,437	10,374
Wyoming	Carbon	Yes	No	1,627	7,720	21,428	47,012	16,261	2,179
	Fremont	Yes	No	3,354	4,307	25,997	59,494	37,903	4,248
	Lincoln	Yes[b]	No	23,322	17,921	26,555	38,107	31,671	8,065
	Sublette	Yes[b]	No	751	9,094	102,821	62,013	19,069	8,449
	Sweetwater	Yes[b]	No	31,369	45,067	52,482	72,947	32,287	10,057
	Uinta	Yes[b]	No	285	4,304	11,421	20,799	17,203	2,232
	Subtotal			60,707	88,413	240,704	300,373	154,394	35,230
Region	Total			88,745	244,434	823,801	1,180,873	260,376	69,878

[a] $PM_{2.5}$ emissions for Colorado were not available, so their emissions were estimated based on typical $PM_{2.5}/PM_{10}$ ratios by source category.

[b] Counties with the most geologically prospective areas: ≥25 gal/ton and ≥25 ft thick for Colorado and Utah, and ≥15 gal/ton and ≥15 ft thick for Wyoming.

Sources: CDPHE (2012c); EPA (2012a); UDEQ (2012b).

category also contributed about 32% of the NO_x emissions. Oil and gas point and area sources combined contributed about 30% of the NO_x. For carbon monoxide (CO), the onroad category was the primary contributor (about 36%) and biogenic (e.g., naturally occurring emissions from vegetation and soils) and forest/agricultural fires were secondary contributors (about 16% each). The biogenic category accounted for most of the VOC emissions (about 83%). For PM_{10} (particulate matter with a mean aerodynamic diameter of 10 μm or less), road dust was the primary contributor (about 43%) and construction was a secondary contributor (about 20%). For $PM_{2.5}$ (particulate matter with a mean aerodynamic diameter of 2.5 μm or less), the point source category was the primary contributor (about 28%) followed by construction (about 23%), road dust (about 17%), and woodburning (about 13%).

In Utah, point sources accounted for most of the SO_x emissions (about 95%) due to high levels of coal-fired power generation, and they were the primary contributors to NO_x emissions (about 57%), due primarily to fossil fuel-fired power generation. Onroad sources were primary contributors to total CO emissions (about 46%) and secondary contributors to total NO_x emissions (about 30%), total PM_{10} emissions (about 37%), and total $PM_{2.5}$ emissions (about 16%). Biogenic sources were primary contributors to total VOC emissions (about 95%). Area sources were primary contributors to total emissions of both PM_{10} (about 52%) and $PM_{2.5}$ (about 63%).

In Wyoming, the fuel combustion category accounted for most of the SO_x emissions (about 92%) due to high levels of coal-fired power generation and was a primary contributor of NO_x emissions (about 56%). Industrial activities accounted for about 17% of the NO_x. For CO, miscellaneous sources (such as fires, agricultural activities, road dust, non-industrial processes, etc.) were primary sources (about 42%), and were followed by biogenic sources (about 19%). For VOCs, the biogenic category was the primary contributor (about 59%), while industrial activities were secondary contributors (about 30%). Miscellaneous sources were the primary contributors to both PM_{10} (about 82%) and $PM_{2.5}$ (about 58%).

3.5.3 Air Quality

Under the Clean Air Act (CAA) which was last amended in 1990, the EPA has set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment (EPA 2012b). NAAQS have been established for six criteria pollutants—sulfur dioxide (SO_2), nitrogen dioxide (NO_2), CO, ozone (O_3), PM_{10} and $PM_{2.5}$, and lead (Pb), as shown in Table 3.5.3-1. The Clean Air Act established two types of NAAQS: primary standards to protect public health, including sensitive populations (e.g., asthmatics, children, and the elderly), and secondary standards to protect public welfare, including protection against degraded visibility and damage to animals, crops, vegetation, and buildings. Any individual state can have its own State Ambient Air Quality Standards (SAAQS), but SAAQS must be at least as stringent as the NAAQS. If a state has no standard corresponding to one of the NAAQS or the SAAQS is not as stringent as the NAAQS, then the NAAQS apply. Colorado has more stringent standards than the NAAQS for SO_2 (CDPHE 2012d). In Utah, the standards are equivalent to the NAAQS for each pollutant (Utah Administrative Code Rule R307-101-1). In

TABLE 3.5.3-1 National Ambient Air Quality Standards (NAAQS), State Ambient Air Quality Standards (SAAQS), and Prevention of Significant Deterioration Increments for the Study Area

		NAAQS[b]		SAAQS			PSD Increment (µg/m³)[f]	
Pollutant[a]	Averaging Time	Standard Value	Standard Type[c]	Colorado	Utah[d]	Wyoming[e]	Class I	Class II
SO_2[g]	1 h	75 ppb[g]	P	–[h]	75 ppb	–	–	–
	3 h	0.5 ppm	S	700 µg/m³ (0.267 ppm)	0.5 ppm	1,300 µg/m³ (0.50 ppm)	25	512
	24 h	–	–	–	–	260 µg/m³ (0.10 ppm)	5	91
	Annual	–	–	–	–	60 µg/m³ (0.02 ppm)	2	20
NO_2	1 h	100 ppb	P	–	100 ppb	–	–	–
	Annual	53 ppb	P, S	–	53 ppb	100 µg/m³ (0.05 ppm)	2.5	25
CO	1 h	35 ppm	P	–	35 ppm	40 mg/m³ (35 ppm)	–	–
	8 h	9 ppm	P	–	9 ppm	10 mg/m³ (9 ppm)	–	–
O_3[i]	8 h	0.075 ppm	P, S	–	0.075 ppm	0.08 ppm	–	–
PM_{10}	24 h	150 µg/m³	P, S	–	150 µg/m³	150 µg/m³	8	30
	Annual	–[i]	–	–	–	50 µg/m³	4	17
$PM_{2.5}$	24 h	35 µg/m³	P, S	–	35 µg/m³	35 µg/m³	2	9
	Annual	15 µg/m³	P, S	–	15 µg/m³	15 µg/m³	1	4
Pb[j]	Rolling 3 mo	0.15 µg/m³	P, S	–	0.15 µg/m	0.15 µg/m³	–	–

Footnotes on next page.

TABLE 3.5.3-1 (Cont.)

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[a] CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter ≤ 2.5 µm; PM_{10} = particulate matter ≤ 10 µm; SO_2 = sulfur dioxide.

[b] Refer to 40 CFR Part 50 and EPA (2012b) for detailed information on attainment determination and reference method for monitoring.

[c] P = primary standards, which set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly; S = secondary standards, which set limits to protect welfare, including protection against decreased visibility, and damage to animals, crops, vegetation, and buildings.

[d] In Utah, the standards are equivalent to the NAAQS for each pollutant.

[e] In addition, the State of Wyoming has adopted standards for hydrogen sulfide (H_2S), suspended sulfates, fluorides, and odors, as well as more stringent standards for SO_2.

[f] All NEPA analysis comparisons to the Prevention of Significant Deterioration (PSD) increments are intended to evaluate a threshold of concern and do not represent a regulatory PSD Increment Consumption Analysis.

[g] Final rule signed June 2, 2010. The 1971 annual and 24-hour SO_2 standards were revoked in the same rulemaking. However, these standards remain in effect until 1 year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

[h] A dash indicates that no standard exists.

[i] Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard ("anti-backsliding").

[j] Final rule signed October 15, 2008. The 1978 lead standard (1.5 $\mu g/m^3$ as a quarterly average) remains in effect until 1 year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

Sources: 40 CFR Part 50; 40 CFR 52.21; 75 FR 64864; Utah Administrative Code Rule R307-101-1; CDPHE (2012d); EPA (2012b); WDEQ (2012c).

addition, the State of Wyoming has adopted standards for hydrogen sulfide (H_2S), suspended sulfates, fluorides, and odors, as well as more stringent standards for SO_2 (WDEQ 2012c).

Except as noted below, existing air quality within the study area is relatively good. EPA designated areas within the study area are classified as in attainment or as unclassifiable/attainment (40 CFR 81.306, 81.345, 81.351; EPA 2012c). A minute portion of tar sands resources are located in the southeastern corner of Utah County, which is currently designated as a nonattainment area for PM_{10} and $PM_{2.5}$ and a maintenance area for CO. The entire Utah County is a nonattainment area for the PM_{10}. However, the $PM_{2.5}$ nonattainment area is limited to the Utah Valley, which is the western half of the county, while the CO maintenance area is limited to the City of Provo. On April 30, 2012, the Upper Green River Basin, which includes Sublette County and parts of Lincoln and Sweetwater Counties, was designated as a marginal nonattainment area for 8-hour ozone based on high wintertime ozone levels (40 CFR 81.351).

For most criteria air pollutants, ambient concentrations are relatively low compared with applicable ambient air quality standards, as shown in Table 3.5.3-2 for each state in the study area. However, recent ozone data acquired at relatively new monitoring sites indicate high ozone concentrations in some portions of the study area.

Ozone is primarily known as a summertime pollutant. The conditions conducive to high ozone concentrations typically include high temperature, low wind speeds, intense solar radiation, and an absence of precipitation (NRC 1992). However, high ozone concentrations have recently been observed in several western rural areas during winter months, even when temperatures are below freezing. Sublette County, Wyoming, is the area that wintertime high ozone levels were first identified, where daily maximum 8-hour ozone levels have frequently exceeded the NAAQS level of 0.075 ppm in wintertime, mostly during January to March. In contrast, ozone exceedances during the summer ozone season (lasting from spring to early fall) are rare in this area.

Individual days with ozone concentrations above 0.075 ppm do not necessarily indicate a violation of the 8-hour ozone NAAQS. The standard is violated only when quality-assured monitoring data indicate that the 3-yr calendar-year average of the annual fourth-highest daily maximum 8-hour average ozone concentration exceeds 0.075 ppm at a specific monitoring location. Table 3.5.3-2 provides the multiyear O_3 fourth-highest 8-hour daily maximum ozone values for comparison with the NAAQS. Because of insufficient data (less than three years), no Colorado or Utah ozone monitors that are nearest to the study area indicate potential ozone violations. However, recent Wyoming ozone concentrations in and near the study area indicate a potential violation of the ozone NAAQS.

Table 3.5.3-3 provides a summary of rural monitor daily maximum values in areas in or near the study area. As shown in the table, maximum daily 8-hour average ozone concentrations above 0.075 ppm have been monitored within the study area at one site in Colorado, and at multiple sites in Utah and Wyoming. For example, monitored daily maximum 8-hour ozone concentrations exceeded 0.075 ppm on 29 days in Boulder within Sublette County, Wyoming, between February 2, 2005, and June 30, 2011; 27 of these days occurred in winter months. The greatest monitored 8-hour ozone concentration of 0.123 ppm was observed in March 2011, along

TABLE 3.5.3-2 Monitored Concentrations Representative of the Study Area[a]

State	Pollutant	Averaging Time	Applicable Standard[b]	Concentration[c]	Note[d]
Colorado	SO_2	1 h	75 ppb	–[e]	–
		3 h	0.267 ppm	–	(See Murphy Ridge, WY)
		24 h	0.14 ppm	–	(See Murphy Ridge, WY)
		Annual	0.03 ppm	–	(See Murphy Ridge, WY)
	NO_2	1 h	100 ppb	–	(See Redwash, UT)
		Annual	0.053 ppm	–	(See Redwash, UT)
	CO	1 h	35 ppm	6.8 ppm (19%)[f]	Grand Junction, Pitkin (2008–2010)
		8 h	9 ppm	2.3 ppm (26%)[f]	Grand Junction, Pitkin (2008–2010)
	O_3	8 h	0.075 ppm	0.064 ppm (85%)[g]	Rifle (2009–2010)
				0.066 ppm (88%)[g]	Palisade (2009–2010)
				0.063 ppm (84%)[g]	Colorado NM (2008–2009)
	PM_{10}	24 h	150 μg/m^3	67 μg/m^3 (45%)	Grand Junction, Powell Bldg. (2008–2010)
	$PM_{2.5}$	24 h	35 μg/m^3	34.5 μg/m^3 (99%)	Grand Junction, Powell Bldg. (2008–2010)
		Annual	15 μg/m^3	9.3 μg/m^3 (62%)	Grand Junction, Powell Bldg. (2008–2010)
Utah	SO_2	1 h	75 ppb	–	–
		3 h	0.5 ppm	–	(See Murphy Ridge, WY)
		24 h	0.14 ppm	–	(See Murphy Ridge, WY)
		Annual	0.03 ppm	–	(See Murphy Ridge, WY)
	NO_2	1 h	100 ppb	34 ppb (34%)[g]	Ouray (2009–2010)[i]
				30 ppb (30%)[g]	Redwash (2009–2010)[i]
		Annual	0.053 ppm	0.010 ppm (19%)[h]	Ouray (2009–2010)[i]
				0.012 ppm (23%)[h]	Redwash (2009–2010)[i]
	CO	1 h	35 ppm	3.9 ppm (11%)[f]	Provo urban area (2008–2010)
		8 h	9 ppm	2.6 ppm (29%)[f]	Provo urban area (2008–2010)
	O_3	8 h	0.075 ppm	0.117 ppm (156%)[g]	Ouray (2009–2010)[i,j]
				0.083 ppm (111%)[g]	Redwash (2009–2010)[i]
				0.064 ppm (85%)	Dinosaur NM (2007–2009)
				0.069 ppm (92%)	Canyonlands NP (2008–2010)
	PM_{10}	24 h	150 μg/m^3	–	(See Grand Junction, CO Powell Bldg.)
		Annual	50 μg/m^3	–	
	$PM_{2.5}$	24 h	35 μg/m^3	–	(See Grand Junction, CO Powell Bldg. and Rock Springs, WY)
		Annual	15 μg/m^3	–	

TABLE 3.5.3-2 (Cont.)

State	Pollutant	Averaging Time	Applicable Standard[b]	Concentration[c]	Note[d]
Wyoming	SO_2	1 h	75 ppb	–	–
		3 h	0.5 ppm	0.006 ppm (1%)[f]	Murphy Ridge (2007–2008)
		24 h	0.10 ppm	0.006 ppm (6%)[f]	Murphy Ridge (2007–2008)
		Annual	0.02 ppm	0.001 ppm (5%)[h]	Murphy Ridge (2007–2008)
	NO_2	1 h	100 ppb	21 ppb (21%)[g]	Murphy Ridge (2007–2008)
		Annual	0.05 ppm	0.007 ppm (13%)[h]	Murphy Ridge (2007–2008)
	CO	1 h	35 ppm	1.6 ppm (5%)[f]	Murphy Ridge (2007–2008)
		8 h	9 ppm	1.5 ppm (17%)[f]	Murphy Ridge (2007–2008)
	O_3	8 h	0.075 ppm	0.067 ppm (89%)[g]	Murphy Ridge (2007–2008)
	PM_{10}	24 h	150 µg/m^3	81 µg/m^3 (54%)[g]	Murphy Ridge (2007–2008)
				64 µg/m^3 (43%)	Rock Springs (2008–2010)
		Annual	50 µg/m^3	25 µg/m^3 (50%)[h]	Rock Springs (2008–2010)
	$PM_{2.5}$	24 h	35 µg/m^3	14.5 µg/m^3 (42%)	Rock Springs (2008–2010)
		Annual	15 µg/m^3	6.2 µg/m^3 (41%)	Rock Springs (2008–2010)

[a] Monitored concentrations are the second-highest for 3-h and 24-h SO_2, 1-h and 8-h CO, and 24-h PM_{10} (3-yr average); 3-yr average of the annual 4th highest daily maximum for 8-h O_3; 3-yr average of the 98th percentile for 24-h $PM_{2.5}$ and 1-h NO_2; 3-yr average of the 99th percentile for 1-h SO_2; and arithmetic mean for annual SO_2, NO_2, and $PM_{2.5}$.

[b] Most restrictive national or state standard.

[c] Values in parentheses are monitored concentrations as a percentage of the applicable standard.

[d] Representative concentrations are based on recent, reasonably complete data in or near the study area.

[e] A dash indicates that no monitoring data are available.

[f] The value shown represents the greatest annual second-maximum monitored value during the data years included for the site.

[g] In some cases, less than three calendar years of recent data were available for pollutants for which the NAAQS format is a 3-yr average. In these cases, data typically reflect complete calendar years. Data sets with complete 2-yr averages for 2009–2010 include Palisade and Rifle, Colorado, and Redwash, Utah. Colorado National Monument data represent complete 2-yr averages for 2008–2009. Murphy Ridge, Wyoming, site data are based on nearly two full calendar years of data from January 1, 2007 through November 12, 2008.

[h] The value shown represents the greatest annual average monitored value during the data years included for the site.

[i] The air quality monitors at Redwash and Ouray are located on Bureau of Indian Affairs land and are operated by Golder Associates as part of a site-specific compliance action (UDEQ 2010b).

[j] In some cases, less than three calendar years of recent data were available for pollutants for which the NAAQS format is a 3-yr average. In these cases, data typically reflect complete calendar years. Data sets with complete 2-yr averages for 2009–2010 include Palisade and Rifle, Colorado, and Redwash, Utah. Data for Ouray, Utah, were limited to calendar year 2010. Colorado National Monument data represent complete 2-yr averages for 2008–2009. Murphy Ridge, Wyoming, site data are based on nearly two full calendar years of data from January 1, 2007, through November 12, 2008.

Source: EPA (2011b).

TABLE 3.5.3-3 Highest Daily Maximum 8-Hour Ozone Concentrations and the Total Number of Exceedance Days at Selected Monitoring Sites within and around the Study Area

State	County	Station Name	Highest Daily Maximum 8-Hour Concentration (ppm)	Total Number of Exceedance Days	Time Period
Colorado	Garfield	Rifle	0.076	2 (0)[b]	6/21/08 – 6/30/11
	Mesa[a]	Colorado NM	0.071	0 (0)	4/19/07 – 9/30/10
		Palisade	0.077	1 (0)	5/31/08 – 06/30/11
	Rio Blanco	Meeker	0.073	0 (0)	1/9/10 – 7/31/11
		Rangely	0.088	3 (3)	8/8/10 – 7/31/11
Utah	San Juan	Canyonlands NP[c]	0.078	2 (0)	1/1/05 – 7/31/11
	Uintah	Dinosaur NM[c]	0.071	0 (0)	4/20/07 – 9/26/10
		Ouray	0.139	61 (61)	7/31/09 – 6/30/11
		Redwash	0.125	51 (51)	7/30/09 – 6/30/11
Wyoming	Fremont[b]	South Pass	0.093	10 (7)	3/15/07 – 6/30/11
	Sublette	Big Piney	0.072	0 (0)	4/1/11 – 6/30/11
		Boulder	0.123	29 (27)	2/2/05 – 6/30/11
		Daniel South	0.084	4 (4)	7/1/05 – 6/30/11
		Jonah	0.102	13 (13)	1/1/05 – 4/22/08
		Juel Spring	0.094	4 (4)	1/1/10 – 3/31/11
		Pinedale	0.089	4 (4)	7/29/09 – 6/30/11
		Wyoming Range	0.083	3 (3)	1/1/11 – 6/30/11
	Sweetwater	Moxa	0.075	0 (0)	5/29/10 – 6/30/11
		OCI #4 Site[d]	0.094	2 (2)	1/2/07 – 9/30/09
		Wamsutter	0.087	1 (1)	3/7/06 – 6/30/11
	Uinta	Murphy Ridge[e]	0.075	0 (0)	1/1/07 – 6/30/11

[a] Not in but near the study area.

[b] Numbers in parentheses denote ozone exceedance days in winter months, from December to March. Of total wintertime exceedances in three states combined, about half of the exceedances have occurred in February, along with about a quarter of the exceedances each in January and March. There was only one ozone exceedance in December.

[a] Not in but near the study area.

[c] NP = National Park; NM = National Monument.

[d] The site is located about 25 mi west-northwest of Rock Springs, Sweetwater County, Wyoming.

[e] The site is located near the Utah–Wyoming border, approximately 9 mi north–northwest of Evanston in Uinta, County, Wyoming.

Source: EPA (2011b).

with the second highest of 0.122 ppm in February 2008 (EPA 2011b). High wintertime ozone levels have also been observed at some monitoring sites in neighboring Fremont and Sweetwater Counties. However, the Big Piney, Moxa, and Murphy Ridge monitors show no daily maximum 8-hour averages above the ozone standard.

On March 12, 2009, the Governor of Wyoming submitted a recommendation to the EPA requesting designation of the Upper Green River Basin in southwest Wyoming as an ozone nonattainment area, based on monitoring results from 2006 through 2008.[10] The proposed nonattainment area includes the entire Sublette County and east-central Lincoln and northwestern Sweetwater Counties, within which a small portion of the study area is situated. As of October 12, 2011, the EPA has made no determination concerning this request.

Air quality modeling indicated that these high-ozone incidents during wintertime result from several factors: high solar radiation due to high elevation enhanced by high albedo[11] caused by snow cover; shallow mixing height below temperature inversion; no or few clouds; stagnant or light winds; and abundant ozone precursors (such as NO_X and VOC) from existing oil and gas development activities (Kotamarthi and Holdridge 2007; Morris et al. 2009). In particular, snow cover plays an important role in UV reflection and insulation from the ground, which reduces the surface heating that promotes the breakup of temperature inversions.

Topographic and meteorological conditions in the study area in Colorado and Utah are quite similar to those in Sublette County, Wyoming. Thus, the elevated wintertime ozone problem is highly likely once ozone precursor emissions are available. Recently, ozone monitoring has begun in Garfield, Mesa, and Rio Blanco Counties, Colorado, and Uintah County in Utah.

Within rural western Colorado, the greatest monitored daily 8-hour maximum ozone concentrations were 0.076 ppm at Rifle, 0.077 ppm at Palisade, and 0.088 ppm in Rangely. Only one day at Palisade and two days at Rifle, which occurred in July, showed monitored concentrations above 0.075 ppm in three years. However, Rangely recorded concentrations exceeded the standard on three days in just under one year. In February 2011, daily maximum 8-hour ozone levels exceeded the NAAQS level for three days in a row, with the highest of 0.088 ppm at Rangely (EPA 2011b).

Within Utah portions of the study area, ozone monitors at the Ouray and Redwash sites in Uintah County and the Canyonlands National Park (NP) site in San Juan County have individual days above 0.075 ppm. In fact, wintertime high ozone is more significant in Uintah County, Utah, compared to Colorado or Wyoming. The Canyonlands NP site has only 2 daily exceedances in more than six years, occurring only in summer months. In contrast, the Ouray and Redwash monitors have 61 and 51 exceedance days, respectively, above the standard in

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[10] Nonattainment status for any area is determined when the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year is 0.075 ppm.

[11] Albedo is defined as solar reflectivity of the earth's surface. Typical values range from 0.1 for thick deciduous forests to 0.9 for fresh snow. When the ground is highly reflective (e.g., snow cover), solar ultraviolet energy is almost doubled.

approximately three years (though only two complete calendar years have been monitored), all of which occurred in winter months. The greatest monitored maximum daily concentrations were 0.139 ppm at the Ouray monitor and 0.125 at the Redwash monitor.

Of total wintertime exceedances in three states combined, about half of the exceedances have occurred in February, along with about a quarter of the exceedances each in January and March. There was only one ozone exceedance in December.

The Prevention of Significant Deterioration (PSD) regulations (40 CFR 52.21), which are designed to limit the growth of air pollution in "clean" areas, apply to all major new and modified sources within attainment and unclassifiable areas. PSD regulations limit increases in ambient concentrations above legally established baseline levels for criteria pollutants as shown in Table 3.5.3-1. Incremental increases in PSD Class I areas are strictly limited, while those in Class II areas allow for moderate emission growth. Most of the oil shale and tar sands resource areas are classified as PSD Class II, except for the tar sands area in or around Arches, Canyonlands, and Capitol Reef NPs in Utah, and the oil shale area immediately upwind of the Flat Tops Wilderness Area (WA) in Colorado. The PSD Class I and Colorado Class I SO_2 increment areas located within 50 mi of the study area are listed in Table 3.5.3-4.[12] Predominant

TABLE 3.5.3-4 PSD Class I and State Category I Areas Located within 50 mi of the Study Area

Classification	Sensitive Receptor Name	Managing Agency[a]	Area (Acres)	State	Distance (mi)[b]
PSD Class I Areas	Arches National Park	DOI-NPS	65,098	UT	32
	Bridger Wilderness Area	USDA-USFS	428,169	WY	30
	Bryce Canyon National Park	DOI-NPS	35,832	UT	47
	Canyonlands National Park	DOI-NPS	337,570	UT	0
	Capitol Reef National Park	DOI-NPS	221,896	UT	0
	Flat Tops Wilderness Area	USDA-USFS	235,230	CO	27
	Fitzpatrick Wilderness Area	USDA-USFS	198,525	WY	48
	Maroon Bells-Snowmass Wilderness Area	USDA-USFS	71,060	CO	45
Colorado Class I SO_2 Increment Areas[c]	Colorado National Monument	DOI-NPS	20,500	CO	34
	Dinosaur National Monument	DOI-NPS	210,000	CO/UT	7

[a] DOI = U.S. Department of the Interior; NPS = National Park Service; USDA = U.S. Department of Agriculture; USFS = U.S. Forest Service.

[b] Shortest distance between the potential lease area and the sensitive area.

[c] Federal Class II area under the CAA, but it has been designated a State of Colorado Class I SO_2 Increment Area.

[12] Although the area is not a designated PSD Class I area, it has been designated as a Category I area by the State of Colorado, with SO_2 increments equivalent to those applicable in a federal Class I area.

wind direction aloft is from the west and southwest in the region; thus, potential air quality for the Class I areas located east and northeast of the study area would be affected.

Federal departments and agencies are prohibited from taking actions in nonattainment and maintenance areas unless they first demonstrate that the actions would conform to the State Implementation Plan (SIP) as it applies to criteria pollutants. Transportation-related projects are subject to requirements for transportation conformity. General conformity requirements apply to stationary sources. Conformity addresses only those criteria pollutants for which the area is in nonattainment or maintenance (e.g., VOCs and NO_X for O_3). If annual source emissions are below specified threshold levels, no conformity determination is required. If the emissions exceed the threshold, a conformity determination must be undertaken to demonstrate how the action will conform to the SIP. The demonstration process includes public notification and response and may require extensive analysis. The EPA proposed new general conformity regulations on January 8, 2008 (58 FR 1402). Subsequently, a substantial revision to Subpart B and a deletion of most of subpart W were promulgated (75 FR 17254, "40 CFR 51 and 93 *Revisions to the General Conformity Regulations*," April 5, 2010).[13]

The CAA gives Federal Land Managers an affirmative responsibility through the New Source Review permitting process to protect the "air quality related values" (AQRVs), such as visibility and acid deposition, from the adverse impacts of air pollution. The Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring program was established in 1985 to aid in the creation of federal and state implementation plans for the protection of visibility in mandatory federal PSD Class I areas (CIRA 2006). Continuous visibility-related data representative of PSD Class I areas (e.g., Canyonlands National Park and Flat Tops Wilderness Area) have been collected within the oil shale and tar sands study area. Visibility in the region is currently the best of the contiguous United States (2004 annual standard visual range of 185 to 220 km [114–137 mi]).

When deposited on snow, dust may shorten snow cover duration by as much as a month (Painter et al. 2007). Earlier spring snowmelt has broad implications for water resources and recreation-based tourism in states where water is scarce (USGCRP 2009). The problem of disturbed desert dust causing regional climate change and early snowmelt is discussed in numerous recent scientific articles. Neff et al. (2008) documented how the phenomenon of dust causing snowmelt is largely coincidental with increased settlement of the American West. The deposition of this disturbed desert dust on snow leads to early snowmelt (Painter et al. 2007). In the Colorado River Basin, these effects are significant. Painter et al. (2010) estimated that disturbed desert soils, traceable to settlement of the American West, landing on mountain snowpack in the Upper Colorado River Basin has resulted in a net loss of approximately 5% of the annual flow of the Colorado River as measured at Lees Ferry, Arizona. It is likely that most

[13] Subpart W required states to develop SIPs for conformity. In August 2005, Congress eliminated this requirement. Because the two subparts were essentially identical, the EPA deleted all of Subpart W except for §51.851, making 40 CFR 93 Subpart B the single regulation for conformity. (The remaining §51.851 deals with requirements for states that choose to submit general conformity SIPs.) The revisions to 40 CFR 93 and 40 CFR 51, Subpart W became effective on July 6, 2010. The rule changes were promulgated at 75 FR 17254–17279, April 5, 2010.

of this dust on mountain snowpack is coming from nearby lands where soil-disturbing activity makes lands susceptible to wind erosion; activities such as energy development, off-road vehicle use, and grazing serve to destabilize soils, making them more susceptible to wind erosion (Belnap et al. 2009).

While climate change could affect dust generation in arid and semi-arid regions, airborne dust also interacts with other atmospheric gases, clouds, and radiation to modify climate as well. Dust enters the atmosphere from natural sources, such as wind erosion or volcanic action, and anthropogenic sources, such as agricultural activities, industrial activities, and traffic on unpaved/paved roads. The amount of airborne dust is variable in space and time and has a wide spectrum of particle sizes, shapes, and chemical compositions. Because of this variability, mineral dust particles can both scatter and absorb incoming and outgoing solar radiation (Seinfeld and Pandis 1998). In the visible part of the spectrum, the light-scattering effect dominates, and mineral dust exerts an overall cooling effect; in the infrared region, mineral dust is an absorber and acts like a greenhouse gas. This leads to a range of possible impacts on the earth's energy budget, commonly expressed in terms of radiative forcing (RF).[14] The anthropogenic dust RF is estimated to be in the range of –0.3 to +0.1 Wm^{-2}. This range includes all the dust's direct radiative effects reported above, assuming a maximum 20% anthropogenic dust fraction (IPCC 2007).

The Clean Air Status and Trends Network (CASTNET), operating since 1987, is a national long-term environmental monitoring program operated by the EPA and the NPS (EPA 2011c). CASTNET collects air pollutants in the form of gases and particles, such as sulfur and nitrogen species, metal cation, particulate chloride ion, and ozone. Sulfur and nitrogen species along with the meteorological measurements are used to estimate dry deposition fluxes using the numerical model. These data provide information for evaluating the effectiveness of national and regional air pollution control programs. Currently there are a total of 86 operational CASTNET sites located in or near rural areas and sensitive ecosystems collecting data on ambient levels of pollutants where urban influences are minimal. Sample stations around the study area include Gothic, Gunnison County, Colorado; Canyonlands National Park, San Juan County, Utah; and Pinedale, Sublette County, Wyoming.

The National Atmospheric Deposition Program (NADP) is a nationwide network monitoring precipitation, deposition chemistry, and atmospheric mercury species (NADP 2011). The program is a cooperative effort among many groups, including federal, state, tribal, and local governmental agencies; educational institutions; private companies; and non-governmental agencies. The NADP consists of five networks:

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[14] The IPCC (2007) defined radiative forcing (RF) as a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the surface, while negative forcing tends to cool it. In the IPCC report, RF values are for 2005 relative to pre-industrial conditions defined at 1750 and are expressed in watts per square meter (Wm^{-2}). For reference, using the global average of 379 ppm for CO_2 in 2005 gives an RF of 1.66 ± 0.17 Wm^{-2}.

- National Trends Network (NTN): provides a long-term record of the acids, nutrients, and base cations in precipitation. This network began operations in 1978 and currently has 250 sites.

- Mercury Deposition Network (MDN): provides data on the geographic distributions and trends of mercury in precipitation. This network joined NADP in 1996 and currently has over 100 sites in the United States and Canada.

- Atmospheric Integrated Research Monitoring Network (AIRMoN): reports daily measurements of the acids, nutrients, and base cations in precipitation for studying and modeling atmospheric processes. This network joined the NADP in 1992 and currently has seven sites.

- Atmospheric Mercury Network (AMNet): reports atmospheric mercury concentrations for determination of mercury dry deposition. This network joined the NADP in 2009 and currently has 21 sites.

- Ammonia Monitoring Network (AMoN): reports atmospheric ammonia concentrations to determine ammonia dry deposition. The network was approved as an official NADP network in October 2010 and currently has about 50 sites.

The NADP sampling sites (all NTN sites) within and around the study area include Sand Spring (Moffat County), and Sunlight Peak and Four Mile Park (Garfield County) in Colorado; Green River (Emery County) and Canyonlands NP (San Juan County) in Utah; and Gypsum Creek and Pinedale (Sublette County) in Wyoming. None of the other network sites are located within or around the study area except a couple of nearby MDN sites. In addition, the USGS also measures individual lake chemistry throughout the study area.

3.6 EXISTING ACOUSTIC ENVIRONMENT (NOISE)

Any pressure variation that the human ear can detect is considered as sound, and noise is defined as unwanted sound. Sound is described in terms of amplitude (perceived as loudness) and frequency (perceived as pitch). Sound pressure levels are typically measured with a logarithmic decibel (dB) scale.[15] To account for human sensitivity to frequencies of sound (i.e., less sensitive to lower and higher frequencies, and most sensitive to sounds between 1 kHz and 5 kHz), A-weighting (denoted by dBA) (Acoustical Society of America 1983, 1985) is

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15 The decibel scale is logarithmic. Scales for measuring most familiar quantities such as length, distance, and temperature are linear. Logarithmic scales compress the values of the measurements and are useful for measuring quantities such as sound levels that can vary over a large range. For example, two linear measurements of 10 units and 1,000,000,000 units might correspond to values of 1 and 9, respectively, on a logarithmic scale. Logarithmic units also add differently than do linear units. For example, if one object is 6 ft long and a second is twice as long, the second object is 12 ft long. For sounds, however, if one sound level is 50 dB and a second is twice as loud, the second sound level will be 60 dB, not 100 (50 + 50) dB.

widely used, which is a good correlation to a human's subjective reaction to sound. Most noise standards, guidelines, and ordinances use the A-weighted scale.

To account for variations of sound with time, several sound descriptors were developed. L_{90} is the sound level exceeded 90% of the time, called residual sound level (or background level), a fairly steady lower sound level on which discrete single events are superimposed. The equivalent-continuous sound level (L_{eq}), if continuous during a specific time period, would contain the same total energy as the actual time-varying sound. In addition, human responses to noise differ depending on the time of the day; for example, humans may be more annoyed by noise during nighttime hours with lower background levels. The day-night average sound level (L_{dn} or DNL) is averaged over a 24-hour period; 10 dB is added to sound levels from 10 p.m. to 7 a.m. to account for the greater sensitivity of most people to nighttime noise. Generally, a 3-dB change over existing noise level is considered a barely discernible difference and a 10-dB increase is subjectively perceived as a doubling in loudness and almost always causes an adverse community response (NWCC 2002).

Background noise is the noise from all sources other than the source of interest. The background noise level can vary considerably depending on the location. Background noise levels in a noisy urban setting can be as high as 75 dBA during the day. In isolated outdoor locations with no wind, vegetation, animals, or running water, background noise may be under 10 dBA. Typical noise levels in rural settings are about 40 dBA during the day and 30 dBA during the night; in wilderness areas, they are on the order of 20 dBA (Harris 1991). According to L_{dn} estimates based on county population density, noise levels in most counties with low population density in the study area would be under 35 dBA, except for the populous Utah County, which has an L_{dn} of 46 dBA (Miller 2002).

While no information is available defining existing noise levels on BLM-administered land in areas of oil shale or tar sands resources, these areas are largely undeveloped, sparsely populated, and remote, and would be expected to have background noise levels of about 35 dBA or less for their L_{dn}. In addition to natural background, noise sources could include agricultural activities, oil and gas development, low-density traffic on rural roads, recreational activities, and aircraft overflights. The identification of specific noise sources, noise levels, and sensitive receptors, such as residences, schools, and hospitals, requires site-specific analyses.

At the federal level, the *Noise Control Act of 1972* and subsequent amendments (*Quiet Communities Act of 1978*, 42 USC 4901-4918) delegate the authority to regulate noise to the states and direct government agencies to comply with local noise regulations. EPA guidelines recommend an L_{dn} of 55 dBA as sufficient to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974). For protection against hearing loss in the general population from nonimpulsive noise, the EPA recommends an L_{eq} of 70 dBA or less over a 40-year period.

Oil shale and tar sands development would have to follow applicable federal, state, or local guidelines/regulations on noise. Of the three states in the study area, only Colorado has a noise statute with quantitative noise limits by zone, as shown in Table 3.6-1. Another rule applicable to oil shale and tar sands development is the Colorado Oil and Gas Conservation

TABLE 3.6-1 Colorado Limits on Maximum Permissible Noise Levels

	Maximum Permissible Noise Levels (dBA)[a]	
Zone	7 a.m. to next 7 p.m.[b]	7 p.m. to next 7 a.m.
Residential	55	50
Commercial	60	55
Light industrial	70	65
Industrial	80	75

[a] At a distance of 25 ft or more from the property line. Periodic, impulsive, or shrill noises are considered a public nuisance at a level of 5 dBA less than those tabulated. Construction projects are subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed, pursuant to any applicable construction permit issued by a proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

[b] The tabulated noise levels may be exceeded by 10 dBA for a period not to exceed 15 minutes in any 1-hour period.

Source: Colorado Noise Statute, Title 25, "Health;" Article 12, "Noise Abatement;" Section 103, "Maximum permissible noise levels." Available at http://www.michie.com/colorado/lpext.dll?f=templates&fn=main-h.htm&cp=.

Commission (COGCC) amended rule 802 "Noise Abatement" (COGCC 2009), which is the same as the Colorado statute. Rio Blanco County in Colorado has a noise standard of 65 dBA, with an exemption for limited periods of construction if carried out during daylight hours (Rio Blanco County 2002). The states of Utah and Wyoming and their counties in the study area do not have quantitative noise guidelines or regulations applicable to oil shale and tar sands development. However, some counties have noise ordinances without quantitative noise limits; for example, Duchesne County, Utah, limits construction and mining activities to 7 a.m. to 9:30 p.m. on weekdays, 8 a.m. to 9:30 p.m. on Saturdays and 9 a.m. to 9:30 p.m. on Sundays and holidays.

3.7 ECOLOGICAL RESOURCES

This section presents information on ecological resources in potential oil shale and tar sands study areas. To the extent possible, descriptions are provided for specific study areas (oil shale basins and STSAs) on the basis of known resource distributions. In some cases, resource status and distributions are less well known and county-level or regional information is used. Descriptions are provided for aquatic resources (Section 3.7.1); plant communities and habitats (Section 3.7.2); wildlife (Section 3.7.3); and threatened, endangered, and sensitive species (Section 3.7.4).

3.7.1 Aquatic Resources

Aquatic habitats include perennial and intermittent streams, springs, and flatwater (lakes and reservoirs) that support fish or other aquatic organisms through at least a portion of the year. The oil shale and tar sands study areas considered within this PEIS fall within the Upper Colorado River Basin hydrographic area, as identified in Section 3.4. Aquatic habitats of the Upper Colorado River Basin in Colorado, Utah, and Wyoming include more than 300,000 acres of natural lakes and impoundments and more than 10,000 mi of perennial streams; of these, approximately 36,000 acres of reservoir habitat (Flaming Gorge Reservoir) and about 650 mi of perennial stream habitat occur within the geologically prospective portions of the oil shale and tar sands study area.

The condition of aquatic habitats is related to hydrologic conditions of associated upland and riparian areas that contribute to a specific stream or water body, and to stream channel characteristics. Aquatic habitat quality typically varies by location and orientation to geographic landforms and vegetation. Riparian vegetation moderates water temperatures, adds structure to the banks to reduce erosion, provides instream habitat for fish and other aquatic organisms, and provides organic material for aquatic macroinvertebrates. Vegetated floodplains dissipate stream energy, store water for later release, provide areas of infiltration for groundwater, and provide rearing areas for juveniles of some fish species when flooded during some periods of the year. The ranges of water temperature, turbidity, and dissolved oxygen within aquatic habitats largely define the areas that are suitable for use by different aquatic organisms. On the basis of these characteristics, aquatic communities within the potentially affected areas are broadly categorized as coldwater or warmwater, although there is actually a continuum of conditions.

Coldwater communities in the study areas typically include fish species in the family Salmonidae, such as mountain whitefish or trout. Conditions that support such species are usually found in ponds, lakes, or reservoirs at higher elevations and in the headwaters of selected rivers and streams that provide cool, clear waters with relatively high dissolved oxygen levels. Because hypolimnetic releases from dams on some large, deep reservoirs can introduce cold, clear waters into some rivers, coldwater assemblages may also become established in sections of warmwater rivers located immediately downstream of dams (i.e., tailwaters). In contrast, warmwater assemblages typically occur at lower elevations, where waters tend to be warmer and more turbid. Warmwater fish communities within the study areas normally include species such as minnows (family Cyprinidae), suckers (family Catostomidae), sunfishes (family Centrarchidae), and catfishes (family Ictaluridae).

Historically, only 12 species of fish were native to the Upper Colorado River Basin (Table 3.7.1-1), including five minnow species, four sucker species, two salmonids, and the mottled sculpin (Tyus et al. 1982). Four of these native species (humpback chub, bonytail, Colorado pikeminnow, and razorback sucker) are now federally listed as endangered, and critical habitat for these species has been designated within the Upper Colorado River Basin (Section 3.7.4). The roundtail chub, bluehead sucker, and flannelmouth sucker are native fishes that reside in large, slow-moving rivers as well as some of the smaller tributary streams within the oil shale and tar sands areas considered in this PEIS. Populations of these three species have declined in recent years and the roundtail chub is currently a candidate for federal listing by the

USFWS. These declines have been attributed, in part, to effects of water development and the introduction of non-native fishes (Bezzerides and Bestgen 2002). Because of their-declining numbers and limited distribution, the roundtail chub, bluehead sucker, and flannelmouth sucker are considered species of special concern within the states of Colorado, Utah, and Wyoming, and are considered sensitive species by the BLM. These three species are managed within Utah, Wyoming, and Colorado under interagency conservation agreements that include specific conservation measures (UDNR 2006a,b). In Wyoming, programs to remove non-native species have been implemented as a conservation measure for roundtail chub, bluehead chub, and flannelmouth sucker. As of 2011, these removal activities have been suspended, and new conservation measures including chemical treatment, downstream barriers, passage structures, and habitat improvements may be implemented in the future (Emmerich 2011).

Another native fish species, the mountain sucker, is listed as a sensitive species by the BLM in Colorado but not in Utah or Wyoming. This species is also listed as a species of special concern by the state of Colorado. However, it is not listed as a sensitive species by the states of Utah and Wyoming, where the populations appear to be stable (Belica and Nibbelink 2006). This species occurs in a wide range of aquatic habitats, including large rivers, lower-elevation creeks, and montane lakes and streams. Mountain sucker are common within the Green River drainage of Wyoming's Green River and Wakshakie Oil Shale Basins (Belica and Nibbelink 2006). In Utah, the mountain sucker is common in the Duchesne River drainage, but less commonly found elsewhere in the main-stem Green or Colorado River drainages of Uinta Oil Shale Basin (Belica and Nibbelink 2006). The mountain sucker is also found in Yampa, Green, White, and Colorado River drainages and is locally abundant in Piceance Creek in Colorado's Piceance oil shale (Belica and Nibbelink 2006).

In addition to native fish species, more than 25 non-native fish species are present in the basin (Table 3.7.1-1), often as a result of intentional introductions (e.g., for establishment of sport fisheries) (Tyus and Saunders 1996). While most of the trout species found within the Upper Colorado River Basin are introduced non-natives (e.g., rainbow, brown, and some strains of cutthroat trout), mountain whitefish and Colorado River cutthroat trout are native to the basin.

Although it was once common within the upper Green River and upper Colorado River watersheds, the Colorado River cutthroat trout is now found only in isolated subdrainages in Colorado, Utah, and Wyoming (Behnke 1992; Hirsch et al. 2006; Cook et al. 2010). The Colorado River cutthroat trout has been designated as a species of special concern by the states of Colorado and Wyoming and has been designated as a Tier I species in Utah. Regions 2 and 4 of the U.S. Forest Service and the BLM in Colorado and Wyoming both classify the Colorado River cutthroat trout as a sensitive species. A conservation agreement for cutthroat trout in the states of Colorado, Utah, and Wyoming has been developed and agreed to by state fish and wildlife agencies, the Ute Indian Tribe (Uintah and Ouray Reservation), and by various federal agencies, including the BLM Colorado, Utah, and Wyoming State Offices (CRCT Conservation Team 2006). That conservation agreement identifies conservation objectives and conservation actions for this species (CRCT Conservation Team 2006).

TABLE 3.7.1-1 Fishes of the Upper Colorado River Basin

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Cyprinidae (Carps and Minnows)			
Grass carp	*Ctenopharyngodon idella*	Introduced	Incidental in the Colorado River and in the lower Green River. Normally occurs in warm, large rivers with moderate diversity of habitats. May also be present in some warmwater impoundments within the Upper Colorado River Basin.
Red shiner	*Cyprinella lutrensis*	Introduced	Widespread, common to abundant. Its principal distribution is in middle and lower sections of larger rivers having warm and usually turbid water. It inhabits perennial or ephemeral riverine habitats and is tolerant of environmental extremes.
Common carp	*Cyprinus carpio*[b]	Introduced	Widespread, common to abundant. It is locally abundant in warmwater impoundments, slack-water riverine habitats, and seasonally flooded habitats. It prefers sheltered habitats with an abundance of aquatic vegetation in warmwater lakes, reservoirs, and rivers.
Utah chub	*Gila atraria*	Introduced	Incidental to rare in the Colorado River, Green River downstream of Flaming Gorge Dam, the lower Yampa River, Duchesne River drainage, and the Price River. It is abundant in Flaming Gorge Reservoir. It prefers littoral and pelagic zones of reservoirs and is generally not found in larger rivers.
Humpback chub	*Gila cypha*	Native	Federally listed as endangered (see Section 3.7.4). Population concentrations are located in Black Rocks and Westwater Canyon in the Colorado River, Desolation and Gray Canyons of the Green River, and Yampa Canyon in the Yampa River. The fish is incidental in the Green River in Whirlpool and Split Mountain Canyons, in the Yampa River in Cross Mountain Canyon; in the lower Little Snake River, and in the lower Gunnison River. It is highly adapted to life in canyon environments. Adult habitat includes deep pools and shoreline eddies; young occupy warm, quiet habitats such as backwaters and eddies.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Cyprinidae (Carps and Minnows) (Cont.)			
Bonytail	*Gila elegans*	Native	Federally listed as endangered (see Section 3.7.4). It is considered to have been extirpated from the Green and Colorado River systems but may persist in extremely low numbers in the main stem. Stocking programs are currently in place to reintroduce this species. It is considered adapted to main-stem rivers, where it has been observed in pools and eddies.
Roundtail chub	*Gila robusta*	Native	Widespread in the Green and Colorado River systems, found in streams and rivers with warmer water. It is generally rare in the middle and extreme lower Green and Colorado Rivers; rare to common elsewhere. Adult habitat includes riffles, runs, pools, eddies, and backwaters with silt-cobble substrate and adjacent to higher-velocity areas. Young occupy low-velocity shoreline habitats.
Sand shiner	*Notropis stramineus*	Introduced	Common to abundant in the middle and lower sections of the Colorado and Green Rivers and the warmwater reaches of other tributaries. It prefers small- to large-sized streams and rivers with permanent flow, seasonally warm water, slow to moderate water velocities, and clear to turbid water.
Fathead minnow	*Pimephales promelas*[b]	Introduced	Widespread, common to abundant in middle and lower sections of larger rivers having warm and usually turbid water. It inhabits a variety of habitats in ponds, lakes, reservoirs, streams, and rivers.
Colorado pikeminnow	*Ptychocheilus lucius*	Native	Federally listed as endangered (see Section 3.7.4). Although rare, it is widely distributed in warmwater reaches of the Colorado and Green Rivers and lower sections of larger tributaries. Adult habitat includes deep, low-velocity runs, pools, and eddies, or seasonally flooded lowlands. Young occupy low-velocity, shallow, shoreline habitats.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Cyprinidae (Carps and Minnows) (Cont.)			
Speckled dace[b]	*Rhinichthys osculu*[b]	Native	Widespread, common to abundant. It occupies permanent or intermittent cool- or warmwater streams and rivers and small to large lakes. In streams and rivers, adults are generally found in shallow runs and riffles with rocky substrates. Young occupy low-velocity shoreline or seasonally flooded habitats.
Catostomidae (Suckers)			
Redside shiner	*Richardsonius balteatus*[b]	Introduced	Rare to common in the Yampa River and upper sections of the Green and Duchesne Rivers. It prefers cool water and is found in a variety of habitats. In streams, it may occur in slow to swift, clear to turbid water and over cobble, gravel, sand, clay, or mud substrates; it is frequently found associated with vegetation.
Creek chub	*Semotilus atromaculatus*	Introduced	Incidental to rare with a very sporadic distribution in the Upper Colorado River Basin. It prefers small streams with clear, cool water, moderate to high gradients, gravel substrate, and well-defined riffles and pools with abundant cover.
Longnose sucker	*Catostomus catostomus*	Introduced	Locally common in the upper portions of the Gunnison River and cool, clear tributaries of the upper Colorado River drainage. It is found in both lakes and streams.
White sucker	*Catostomus commersoni*	Introduced	Rare to common in reaches of the Yampa River and in upper and middle sections of the Green River; abundant in Flaming Gorge Reservoir; common to abundant in the Gunnison River. It is a habitat generalist found in lakes, reservoirs, streams, and rivers. In streams and rivers, it prefers deep riffles, pools, and shallow runs over gravel or cobble substrates.
Bluehead sucker	*Catostomus discobolus*	Native	Widespread, rare to common. It is found in a variety of habitats, ranging from cool, clear streams to warm, turbid rivers. Adults prefer deep riffles or shallow runs over rocky substrates. Young occupy low-velocity shoreline or seasonally flooded habitats.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Catostomidae (Suckers) (Cont.)			
Flannelmouth sucker	*Catostomus latipinnis*	Native	Widespread, rare to common. It is found in warmwater reaches of larger river channels. Adults typically occupy pools and deeper runs, eddies, and shorelines. Young occupy low-velocity shoreline or seasonally flooded habitats.
Mountain sucker	*Catostomus platyrhynchus*	Native	Common in the upper Green River drainage in Wyoming; incidental to rare in the Green River of Utah upstream of the Yampa River confluence and in headwaters of the Yampa and White Rivers; common in tributaries of the Duchesne, Price, and San Rafael Rivers in Utah; locally abundant in Piceance Creek in Colorado. It prefers cool, clear streams with rocky substrates.
Razorback sucker	*Xyrauchen texanus*	Native	Federally listed as endangered (see Section 3.7.4). It is found in warmwater reaches of the Green and Colorado Rivers and lower portions of major tributaries; it primarily occurs in flat-water sections of the middle Green River between the Duchesne and Yampa Rivers and between Palisade and Loma in the Colorado River. Larvae have recently been found in the lower reaches of the White River in Utah, indicating that adults are also present during some periods of the year and that successful reproduction is occurring in the White River. Adult habitat includes runs, pools, eddies, and seasonally flooded lowlands. Young presumably require nursery habitat with quiet, warm, shallow water such as tributary mouths, backwaters, and especially floodplain wetlands.
Ictaluridae (Bullheads and Catfishes)			
Black bullhead	*Ameiurus melas*[b]	Introduced	Sporadic distribution in middle and lower sections of the Green, Yampa, Duchesne, and White Rivers. It is incidental to rare in main-channel habitats and common to abundant in inundated floodplain habitat adjacent to the middle Green River. It is found in turbid backwaters, seasonally flooded habitats, impoundments, and low-gradient river reaches with muddy bottoms.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Ictaluridae (Bullheads and Catfishes) (Cont.)			
Channel catfish	*Ictalurus punctatus*[b]	Introduced	Widespread, common to abundant in middle and lower sections of larger rivers. Its optimum riverine habitat has warm water and a diversity of velocities, depths, and structural features that provide cover and feeding areas. In the Green and Yampa Rivers, it is most abundant in rocky, turbulent, high-gradient canyon habitats.
Esocidae (Pikes)			
Northern pike	*Esox lucius*	Introduced	Occurs in several rivers and impoundments but is infrequently collected, except in reaches of the Yampa River and middle Green River, where it is often caught during spring sampling for adult Colorado pikeminnow and razorback suckers. It primarily inhabits vegetated ponds, marshes, and larger lakes; deep pools, eddies, mouths of tributaries; and seasonally flooded habitats of larger rivers.
Salmonidae (Trouts)			
Cutthroat trout[c]	*Oncorhynchus clarki*[c]	Native and introduced[c]	Rare to common in certain upstream river reaches (e.g., Green River downstream of Flaming Gorge Dam; stocked in tailwaters) or impoundments. It prefers cold, clear headwater streams. Native Colorado River cutthroat trout are present mostly as remnant populations in isolated high-elevation tributaries and are managed under interagency conservation agreements among state, tribal, and federal agencies (CRCT Conservation Team 2006).
Rainbow trout	*Oncorhynchus mykiss*	Introduced	Common to abundant in the Green River upstream of the Yampa River confluence (stocked in Flaming Gorge Reservoir and tailwaters), incidental to rare downstream, and common to abundant in upper sections of the Yampa, Duchesne, and White River drainages. It prefers pools, eddies, runs, and riffles in streams with gravel or cobble substrates.
Kokanee (landlocked form of Sockeye salmon)	*Oncorhynchus nerka*	Introduced	Common in Fontenelle and Flaming Gorge Reservoirs on the Green River and the Aspinall Reservoirs on the Gunnison River; rare in tailwaters, where it is a probable escapee from the reservoirs. It prefers pelagic zones of reservoirs.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Salmonidae (Trouts) (Cont.)			
Mountain whitefish	*Prosopium williamsoni*	Native	Incidental to rare in the Green River upstream of the Yampa River confluence and in lower sections of the Yampa and White Rivers; common in upper sections of the Yampa, White, and Duchesne Rivers. It prefers streams and rivers with cool, swift water and gravel or rubble substrates.
Brown trout	*Salmo trutta*	Introduced	Common in cool- and cold-water reaches of the Colorado River, rare to common in the Green River upstream of the Yampa River confluence and in upper sections of the Duchesne River drainage, and rare in the Yampa and White Rivers. It prefers deep pools, riffles, and runs with sand or cobble substrates and moderate to fast current.
Brook trout	*Salvelinus fontinalis*	Introduced	Rare to common in the Green River upstream of the Yampa River confluence (stocked in Flaming Gorge Dam tailwaters) and in Soldier Creek and Strawberry Reservoirs; found in headwater areas of tributaries. It prefers clear headwater streams with gravel substrate.
Lake trout	*Salvelinus namaycush*	Introduced	Present in Flaming Gorge and Fontenelle Reservoirs on the Green River and in Blue Mesa Reservoir on the Gunnison River. Prefers cold, deep waters of large lakes and reservoirs.
Gadidae (Cods)			
Burbot	*Lota lota*	Introduced	Relatively new introduction and abundance status is unclear. Present in the Green River, including Flaming Gorge and Fontenelle Reservoirs. The burbot prefers cold waters in streams and lakes and impoundments and usually occurs near the bottom.
Cyprinodontidae (Killifishes)			
Plains killifish	*Fundulus kansae*	Introduced	Locally common in some warmwater ponds and in some river backwaters in the Colorado River subbasin.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Poeciliidae (Livebearers)			
Western mosquitofish	*Gambusia affinis*	Introduced	Locally common in some warmwater ponds and in some river backwaters in the Colorado River subbasin; incidental to rare, very sporadic distribution in the Green River subbasin. It prefers warm, slack-water areas.
Gasterosteidae (Sticklebacks)			
Brook stickleback	*Culaea inconstans*	Introduced	Incidental in the upper Yampa River drainages and in the middle Green River between Jensen and Ouray, Utah (almost exclusively in floodplain habitat). It prefers clear, cool, densely vegetated waters of slow-flowing small streams or ponds.
Cottidae (Sculpins)			
Mottled sculpin	*Cottus bairdi*	Native	Rare to common in the portions of the Colorado and Green Rivers, and in the Gunnison, Yampa, Duchesne, Price, and San Rafael Rivers. It prefers cool-water riffles and deep runs with rocky substrates in streams and rivers.
Bear Lake sculpin	*Cottus extensus*	Introduced	Naturally endemic to Bear Lake, on the Utah-Idaho border. It has been introduced and become established in Flaming Gorge Reservoir. It is listed as a sensitive species by the Utah Division of Wildlife Resources. It prefers bottom lake habitat and spawns among rocks close to the shoreline.
Centrarchidae (Sunfishes)			
Green sunfish	*Lepomis cyanellus*	Introduced	Common to abundant in some warmwater lakes and ponds. Generally rare in the middle Green and lower Yampa, Duchesne, and White Rivers; locally common in the Green River near the confluences of the Duchesne and White Rivers and in adjacent inundated floodplain habitat; locally common to abundant in some areas of the Gunnison and Colorado Rivers. It prefers backwater areas of warmwater streams or weed beds in warmwater lakes and reservoirs.

TABLE 3.7.1-1 (Cont.)

Family and Common Name	Scientific Name	Origin	Present Distribution in the Upper Colorado River Basin and Comments[a]
Centrarchidae (Sunfishes) (Cont.)			
Bluegill	*Lepomis macrochirus*	Introduced	Incidental in riverine habitats, but locally common in some warmwater ponds and reservoirs. It prefers shallow, warm lakes and ponds or slow-moving areas of clear streams with abundant aquatic vegetation.
Smallmouth bass	*Micropterus dolomieui*	Introduced	Present in some cool and warmwater lakes, ponds, and reservoirs. Common along rocky shorelines in Flaming Gorge Reservoir. Generally rare along the Green River in Utah but locally common in areas near the confluences of the Duchesne and White Rivers; locally common in some areas of the middle and lower Yampa River. It prefers clear, wide, fast-flowing runs and flowing pools with gravel or rubble substrates.
Largemouth bass	*Micropterus salmoides*	Introduced	Present in some warmwater lakes and ponds and in the Colorado and Gunnison Rivers. Locally common in the lower Yampa River and in the Green River downstream of the Yampa River confluence; rare in Flaming Gorge Reservoir. It prefers clear, quiet waters in rivers with aquatic vegetation or vegetated littoral zones in lakes and reservoirs.
Black crappie	*Pomoxis nigromaculatus*	Introduced	Present in some warmwater lakes and ponds; incidental in lower portions of the Colorado River and in the Green River near the confluences of the Duchesne and White Rivers. It inhabits clear, warm, quiet waters of ponds, lakes, and backwaters of larger rivers; it is generally found where there is abundant aquatic vegetation.
Percidae (Perches)			
Walleye	*Sander vitreus*[d]	Introduced	Incidental to rare in the Duchesne River, incidental in the Yampa and middle Green Rivers, and incidental in the lower Colorado River. It prefers large streams, rivers, and lakes with moderately deep, clear water, often found in slow, shallow runs, usually associated with emergent or bank vegetation.

Footnotes on next page.

TABLE 3.7.1-1 (Cont.)

[a] Abundant = occurring in large numbers and consistently collected in a designated area; common = occurring in moderate numbers and frequently collected in a designated area; rare = occurring in low numbers, either in a restricted area or having a sporadic distribution over a larger area; incidental = occurring in very low numbers and known from only a few collections.

[b] The Kendall Warm Springs dace (*Rhinichthys osculus thermalis*) is a federally listed endangered subspecies restricted to Kendall Warm Springs in the upper Green River drainage, Wyoming (see Section 3.7.4).

[c] Includes native Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*), non-native Snake River Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*), and non-native Bear Lake Bonneville cutthroat trout (*Oncorhynchus clarki utah*).

[d] Scientific name changed from *Stizostedion vitreum* (Nelson et al. 2004).

Sources: Behnke et al. (1982); Tyus et al. (1982); Miller and Hubert (1990); Muth and Nesler (1993); Muth et al. (2000); Lentsch et al. (1996); Modde and Haines (1996); McAda (2003); Woodling (1985); Tyrus and Saunders (1996).

Arid desert ecosystems are particularly susceptible to climate change because of their already harsh temperature and precipitation conditions (Archer and Predick 2008). The effects of climate change on the Colorado River Basin could be severe and may result in the loss of some endemic fish species as well as invertebrate and plant species. Climate change is predicted to produce the following changes in the physical characteristics of the Colorado River Basin:

- An increase in temperature (1 to 3°C over the next 20 to 60 years; Belnap and Campbell 2011);

- A reduction in runoff (6 to 20% decrease by 2050 in the upper Colorado River Basin; Ray et al. 2008);

- A reduction in streamflow (decreases from about 5 to 20% per 1°C; Ray et al. 2008);

- A reduction in precipitation (not all studies agree on the change in precipitation, but most predict an increase in drought length and intensity and rain storm intensity; Cayan et al. 2010; Belnap and Campbell 2011); and

- A reduction in annual snowpack (10 to 20% reduction above 8,200 ft and a larger reduction below 8,200 ft; Ray et al. 2008).

An increase in water temperature could make some streams or stream segments uninhabitable for some native aquatic species. Since many aquatic species in the Southwest already live in water at the upper limits of their temperature tolerance, any temperature increase could further limit their habitat range or result in extirpation. Water temperature is also an important regulator of fish migration and insect emergence, and the projected temperature increase could disrupt the timing of life-cycle stages of some organisms (Whitehead et al. 2009).

Decreased precipitation, snowpack, and runoff would lead to more frequent and persistent droughts in the Colorado River Basin. Increases in drought conditions could result in an increase in water salinity throughout the basin (Everard 1996). Higher salinities may allow establishment of new non-native species and may allow invasive species already established (e.g., the red shiner, western mosquitofish, and plains killifish) with higher salinity tolerances than native species to become more dominant (Rahel and Olden 2008). Drought in the arid Southwestern United States also leads to drying of ephemeral or shallow streams, which reduces connectivity of populations and can result in extirpation of native fish and insect populations (Propst et al. 2008; Boulton and Lake 2008). Reduced connectivity also eliminates an important dispersal mechanism for aquatic insects (Boulton and Lake 2008).

A decrease in streamflow may quickly cause local extinctions of insects that require fast-flowing and well-oxygenated water, such as mayflies and caddisflies (Boulton and Lake 2008), and could favor fish species that prefer slower-moving and shallower waters. A reduction in streamflow coupled with increased water temperatures would decrease the amount of dissolved oxygen in some basin waters and could lead to hypoxia (Whitehead et al. 2009). Prolonged periods of low stream flows associated with climate change may also increase the establishment success of some non-native species. During times of low flow, some invasive species (e.g., red shiner, common carp, western mosquitofish, and crayfish) can dominate the fish communities in arid regions (Rahel and Olden 2008; Martinez 2011).

The drying of ephemeral waters and decreases in water depth of permanent waters would result in a decrease in spatial or temporal extent of habitat available to aquatic species as well as a reduction in habitat complexity (Lake 2003). The Colorado River Basin supports a unique biotic community of fishes well adapted to arid conditions, and historical species-level endemism for fishes within the region is high (Minckley et al. 2003). This decrease in habitat range could potentially lead to a reduction in the number of distinct populations of endemics and a greater risk of extinction. Reduction in habitat could also result in increased competition among species for food and space resources, as well as an increase in predation.

An increase in rainstorm intensity in the Southwestern United States would periodically increase erosion rates and subsequently increase turbidity of streams (Archer and Predick 2008); this could impact species that prefer less turbid conditions. More intense rainfall is also likely to increase runoff from developed areas during storm events and could increase the amount of chemicals deposited into receiving streams (Whitehead et al. 2009). Increased nitrogen and phosphorus in streams from agricultural runoff promotes the growth of algal blooms, which can contribute to the creation of hypoxic conditions.

The following subsections provide additional detail about aquatic resources within the vicinity of each of the oil shale basins and STSAs.

3.7.1.1 Oil Shale Basins

The principal hydrologic subbasins that could potentially receive waters from the four oil shale basins are the Great Divide–Upper Green River subbasin, the White–Yampa River subbasin, the Colorado Headwaters subbasin, and the Lower Green River subbasin. The major rivers draining these subbasins include the Green River, the White River, the Yampa River, and the Colorado River. The only major reservoir that falls within the potentially affected areas is Flaming Gorge Reservoir. In addition, several smaller rivers and streams, as well as a number of small natural lakes and impoundments, occur within the potentially affected areas.

3.7.1.1.1 Green River Oil Shale Basin. Riverine habitats within the Green River Oil Shale Basin are associated with portions of the main stem of the Green River in Wyoming, between Fontenelle Reservoir and Flaming Gorge Reservoir, and with various perennial and intermittent tributaries to the upper Green River. In total, there are approximately 205 mi of perennial stream habitat located within the geologically prospective portion of the Green River Oil Shale Basin. The upstream half of Flaming Gorge Reservoir (approximately 36,000 acres) and a number of small reservoirs, lakes, and ponds also fall within the potentially affected area. The oil shale areas are located at least 0.5 mi from Fontenelle Reservoir.

The fish community in Flaming Gorge Reservoir consists primarily of introduced species, including lake trout, brown trout, rainbow trout, cutthroat trout, kokanee, white sucker, smallmouth bass, channel catfish, common carp, Utah chub, redside shiner, and the Bear Lake sculpin. It also supports small numbers of native fish species, including flannelmouth sucker, mountain whitefish, and the mottled sculpin (BOR 2005).

Rainbow trout have been annually stocked in Flaming Gorge Reservoir since it was filled, and this species provides the bulk of the angler harvest. Kokanee were stocked during the mid-1960s and have developed naturally reproducing fisheries. After rainbow trout, kokanee are typically second in harvest and popularity with anglers. Other sport fish occasionally stocked in the reservoir include brown trout and channel catfish. Lake trout entered Flaming Gorge Reservoir from the upper Green River drainage and have also become established as a wild population. Smallmouth bass were introduced into Flaming Gorge Reservoir in the 1960s to promote growth of rainbow trout by reducing the Utah chub population (Teuscher and Luecke 1996), and now occur in rocky shoreline habitat throughout Flaming Gorge Reservoir (BOR 2005).

Burbot (also called ling), a member of the cod family, were illegally introduced into the Green River in 2005 and have now become established in Flaming Gorge and Fontenelle Reservoirs as well as the connecting portion of the Green River and some tributaries (WGFD 2006). Small numbers of burbot may also be present in the Green River downstream of Flaming Gorge Dam, as evidenced by the capture of a single individual during the summer of 2010. These fish are aggressive predators that feed on other fish and invertebrates, and there are concerns that this species could negatively affect both game and nongame fish populations in the upper Green River subbasin.

Several streams within the geologically prospective oil shale areas in the Green River Oil Shale Basin are considered Crucial Priority Habitat Areas by the Wyoming Game and Fish Department (WGFD) based on significant biological and ecological values and ecologically important species or communities. The WGFD has also designated Enhancement Priority Areas targeted for habitat enhancement activities. Within the geologically prospective oil shale areas, Bitter Creek, Flaming Gorge, and Hams Fork have been classified as Crucial Aquatic Habitat Areas, while the Lower Big Sandy has been designated a Priority Enhancement Area. The Green River, Sage Creek, and Blacks Fork are Crucial Aquatic Habitat and Enhancement Priority Areas (http://gf.state.wy.us/habitat/PriorityAreas/GreenRiver/index.asp). Several other Crucial Aquatic Habitat and Enhancement Priority Areas are present within in the Green River Basin (http://gf.state.wy.us/habitat/PriorityAreas/GreenRiver/index.asp). A significant, nationally recognized trout fishery exists in the portion of the main stem of the Green River within this region; the fishery includes target species such as rainbow, brown, brook, and cutthroat trout. The WGFD manages the fishery through the use of various regulations, including creel limits, size limits, and tackle restrictions. On the basis of surveys conducted in April 2005, the main stem of the Green River in the vicinity of Seedskadee National Wildlife Refuge (NWR) was estimated to have high densities of catchable-sized trout (more than 190 trout per mile of river) (WGFD 2006). Trout fisheries also exist in the Big Sandy and Little Sandy River from their confluence near Farson to their headwaters. In the Green River Oil Shale Basin, between Flaming Gorge and Wyoming Highway 191, there are tributaries to the Green River such as

Sage Creek and Currant Creek that contain Colorado River cutthroat trout populations (Hirsch et al. 2006). Populations in Current Creek are 80–89% genetically pure.

As indicated in Section 3.7.1, bluehead sucker, flannelmouth sucker, and roundtail chub are all considered extremely rare species of special concern within the state of Wyoming, and are considered sensitive species by the BLM. All three of these species occur within the geologically prospective oil shale areas in the Green River Oil Shale Basin. Bluehead sucker occur in the Big and Little Sandy Rivers, the main-stem Green River, Hams Fork River, and the Blacks Fork River; a reproductively isolated population also occurs in the Ringdahl Reservoir, located in the Henrys Fork drainage (WGFD 2010a). Flannelmouth sucker are known to occur in the Big and Little Sandy Rivers, the main-stem Green River, Bitter Creek, the Blacks Fork, Hams Fork, Smiths Fork, Muddy Creek (tributary to Blacks Fork), and Henrys Fork drainages (WGFD 2010a). Hybridization of native sucker species with white suckers is considered a potential threat to the maintenance of the populations of the native species. At present, the only known population of flannelmouth sucker in Wyoming that is reproductively isolated from white sucker is found in the upper Bitter Creek drainage (WGFD 2010a). Roundtail chub are known to occur in the Blacks Fork drainage, including the Hams Fork and Muddy Creek (WGFD 2010a).

None of the four endangered Upper Colorado River fish species occur in the Flaming Gorge Reservoir or in the upstream portions of the Green River subbasin. Historically, the Colorado pikeminnow probably occurred in the upper Green River as far as Green River, Wyoming, and records indicate that the humpback chub and the bonytail were present upstream of the current location of Flaming Gorge Dam (Muth et al. 2000). Historic occurrence of the razorback sucker upstream of the location of Flaming Gorge Dam is less likely (Muth et al. 2000).

3.7.1.1.2 Washakie Oil Shale Basin. Two perennial streams (totaling less than 17 mi of stream habitat) pass through the portion of the Washakie Oil Shale Basin where extraction from the oil shale deposits is considered feasible. Approximately 7 mi of Vermillion Creek and 10 mi of Alkali Creek pass through the area. No significant fisheries are known to occur within these portions of these streams, although trout habitat exists in portions of the North Fork of the Vermillion River, located upstream of the prospective oil shale extraction areas. Historically, approximately 56 mi (0.3%) of the Vermillion Creek watershed were occupied by Colorado River cutthroat trout, although none of the historically occupied habitat currently contains Colorado River cutthroat trout (Hirsch et al. 2006).

Another perennial stream, Bitter Creek, is located within 0.25 mi of the potentially affected area. This stream drainage did not historically support Colorado River cutthroat trout (Hirsch et al. 2006), but does support a warmwater native fish assemblage identified by the WGFD as a Priority Enhancement Area (http://gf.state.wy.us/habitat/PriorityAreas/GreenRiver/index.asp). Native species in this stream include flannelmouth sucker, speckled dace, and mountain sucker (Carter and Hubert 1995).

3.7.1.1.3 Uinta Oil Shale Basin. Aquatic habitats within the Uinta Oil Shale Basin are primarily associated with the Green River watershed, although some small perennial and intermittent tributaries of the upper Colorado River subbasin are present in the southeastern portion of the oil shale basin. In total, approximately 193 mi of perennial stream habitat falls within the geologically prospective area of the Uinta Oil Shale Basin. The portion of the Uinta Oil Shale Basin from which extraction is considered feasible neighbors approximately 70 mi of the middle Green River downstream from Ouray, Utah. In addition, a substantial portion of the lower White River, a significant tributary to the middle Green River, falls within the potentially affected area. Several reservoirs, ponds, and small lakes also fall within the Uinta Oil Shale Basin.

The portions of the Green River and the White River within and adjacent to the Uinta Oil Shale Basin are predominantly inhabited by warmwater native and non-native fishes (Lentsch et al. 2000; Muth et al. 2000). The predominant fish species likely to be present within adjacent portions of these two rivers and associated tributaries belong to families Cyprinidae (minnows), Catosomidae (suckers), Cottidae (sculpins), Centrachidae (sunfishes), and Ictaluridae (catfishes). This section of the Green River is a concentration area for federally endangered Colorado pikeminnow and razorback sucker; bonytail and humpback chub could also occur in this area (Section 3.7.4), although less commonly (Muth et al. 2000). Colorado pikeminnow have been reported from the White River within this oil shale basin (Lentsch et al. 2000). Larval razorback sucker were recently found in the lower reaches of the White River in Utah, 5 mi upstream of the confluence with the Green River, indicating that adults are present during some periods of the year and that successful reproduction is occurring in the White River.

Bitter Creek and Evacuation Creek are intermittent through or adjacent to the study area and do not continually support populations of fish. Speckled dace and mountain sucker could be found within that portion of Bitter Creek flowing through the study area during high flow periods, although the stream frequently dries up during hot, dry summers. No fish species are known to use the streams or ponds emanating from springs or flowing wells in the Asphalt Wash drainage (BLM 2006e).

Pariette Draw, a tributary to the Green River in the northwestern portion of the study area, is used to supply water to the Pariette Wetlands. These wetlands, which are managed primarily for waterfowl, contain a number of small warmwater ponds.

3.7.1.1.4 Piceance Basin. As identified in Section 3.4, the Piceance Oil Shale Basin is drained by three major river systems: (1) the White River basin to the north, (2) the Colorado River basin through the central portion, and (3) the Gunnison River basin to the south. However, the Gunnison River subbasin does not fall within the portion of the Piceance Basin that is considered feasible for extraction of oil shale resources. In total, approximately 128 mi of perennial stream habitat occurs within this oil shale basin.

Although the White River itself does not fall within the study area, two principal tributaries to the upper White River, Yellow Creek and Piceance Creek, are within the study area, along with several of their tributaries (Corral Gulch, Ryan Gulch, Black Sulphur Creek, Hunter Creek, and Willow Creek). Some portions of these smaller tributaries go dry during some seasons of the year and do not sustain fish for portions of the year. The lower reaches of Yellow Creek (downstream of Barcus Creek) support populations of speckled dace, brown trout, and mountain sucker (Chadwick Ecological Consultants 2002, as cited in BLM 2006g). Fawn Creek also falls within the study area and supports mountain sucker (Belica and Nibbelink 2006). Although mostly privately owned, the lower reaches of Willow Creek support speckled dace and mountain sucker. Rainbow and brook trout have been observed farther upstream (BLM 2011c). Two small tributaries to Parachute Creek (East and West Forks of Parachute Creek) are located within or adjacent to the study area. Parachute Creek itself is a tributary to the upper Colorado River. Because the conditions in these streams represent a transition between cold- and warmwater stream segments, fish species include trout, as well as some species of suckers and minnows. Piceance Creek supports populations of sensitive native fish, including flannelmouth sucker, mountain sucker (Belica and Nibbelink 2006), and speckled dace. Trout that appear occasionally in collections are probably stocked fish that have escaped from privately owned upstream ponds (BLM 2006d).

Although no endangered fish occur within the study area itself, Colorado pikeminnow occupy the lower White River downstream of Taylor Draw dam, located approximately 10 mi west of the study area (Martinez et al. 1994). The White River and its 100-year floodplain below Rio Blanco Lake (approximately 3 mi from the study area) have been designated as critical habitat for the Colorado pikeminnow. Martinez et al. (1994) reported that the Colorado pikeminnow has been extirpated upstream of Taylor Draw Dam. The razorback sucker, also federally listed as an endangered species, is unlikely to be present in the upper reaches of the White River, although larval razorback sucker have recently been observed in the lower portion of the White River near the confluence with the Green River. This indicates that razorback suckers are successfully spawning in the lower White River. Additional information about the Colorado River Basin endangered fish species is presented in Section 3.7.4.

The upstream portion of Black Sulphur Creek within the study area supports a self-sustaining population of Colorado River cutthroat trout, although there is evidence of hybridization with rainbow trout. Because it is a relatively remote location with barriers to movement from downstream locations (i.e., physical barriers and water diversions), this stream has been identified as having potential as a reintroduction location for genetically pure strains of Colorado River cutthroat trout. Populations of mountain sucker exist in the lower reaches of Black Sulphur Creek (BLM 2011c).

Angling opportunities within the vicinity of the Piceance Oil Shale Basin are provided by some of the perennial streams and by several nearby reservoirs that are located outside of the oil shale study area. Portions of the Yampa River currently provide smallmouth bass and northern pike angling opportunities, although the presence of these non-native species is considered detrimental to efforts to recover Colorado River Basin endangered fish within the reaches of the Yampa River that are designated as critical habitat. Kenney Reservoir, located approximately 25 mi from the oil shale basin study area, provides angling opportunities for black crappie and other warmwater species. Rifle Gap Reservoir and Harvey Gap Reservoir, located east of the study area, provide angling opportunities for northern pike, walleye, yellow perch, and trout.

Parachute Creek, located southwest of the oil shale study area, provides angling opportunities for trout.

At least five species of native freshwater mussel (fingernail and pill clams, family Sphaeriidae) inhabit streams and rivers in portions of Rio Blanco and Garfield Counties where oil shale development could occur (Wu and Brandauer 1978). Little is known about the historic distribution of this group of small clams, and the current status of these mussels in Colorado is unknown (Sovell and Guralnick 2004; Nelson and Guralnick 2007). However, some closely related species in other areas of North America have experienced significant declines in populations in the past few decades (Wilson et al. 1995). Native mussel species have been collected in the both the White River and Piceance Creek in the vicinity of the Piceance Oil Shale Basin (Sovell and Guralnick 2004; Nelson and Guralnick 2007).

3.7.1.2 Special Tar Sand Areas

The Asphalt Ridge, Raven Ridge, Pariette, Hill Creek, and P.R. Spring STSAs are all within areas that eventually drain to the Green River. Warmwater aquatic communities, similar to those described previously for the Uinta Oil Shale Basin occur within these areas. Many of the drainages within these areas are intermittent. However, the Asphalt Ridge area is adjacent to the Green River itself. Other perennial tributaries of the Green River within these STSAs include Ashley Creek, Cliff Creek, and Pariette Draw. While no endangered fishes would be expected to occur directly within these STSAs, they could occur in nearby areas of the Green River (Section 3.7.4). In total, approximately 107 mi of perennial stream habitat occur within the STSAs.

The Sunnyside STSA is drained by portions of Dry Creek, Cottonwood Canyon, and Nine Mile Creek, which eventually drain to the Green River via Nine Mile Creek. No significant fisheries are known to occur within these areas, although warmwater fish communities would be expected to be present in these drainages. In addition, an intermittent drainage, Range Creek, occurs within this area. Range Creek provides habitat for small populations of brown and cutthroat trout.

The Argyle Canyon STSA is within the vicinity of a single drainage, the South Fork of Avintaquin Creek. This creek, which is a tributary of the Strawberry River, may support trout, although information is limited. Hirsch et al. (2006) identify this creek as having poor habitat for Colorado River cutthroat trout. The Argyle Canyon STSA is also traversed by Argyle Creek, which is a tributary of Nine Mile Creek.

In addition to being drained by a number of intermittent drainages, the San Rafael STSA surrounds a portion of the San Rafael River. Fish in the San Rafael River, which is a tributary to the lower Green River, include a high proportion of warmwater native fishes (approximately 70%), including bluehead sucker, flannelmouth sucker, roundtail chub, speckled dace, and Colorado pikeminnow (Tyus and Saunders 2001). The San Rafael River is also used by endangered fishes. Colorado pikeminnow have been captured in the lower 35 mi of the

San Rafael River, and small numbers of razorback suckers occur in the Green River near the mouth of the San Rafael River (Muth et al. 2000; Tyus and Saunders 2001).

The Tar Sand Triangle STSA is drained by Big Water and Horse Canyons to the northeast and by French Spring Fork, Happy Canyon, and the Dirty Devil River to the northwest and west. Big Water and Horse Canyons are perennial tributaries to the Colorado River; French Spring Fork and Happy Canyon are ephemeral or intermittent drainages that enter the Dirty Devil River. The Dirty Devil River itself is a perennial stream that drains into the northern end of Lake Powell and supports a warmwater fish community. The Dirty Devil arm of Lake Powell is included in designated critical habitat for the razorback sucker (59 FR 13374), and small numbers of razorback suckers have been found in Lake Powell near the mouth of the Dirty Devil River (Section 3.7.4).

The Circle Cliffs and White Canyon STSAs both are also drained by intermittent or ephemeral tributaries that eventually drain to Lake Powell. Because these areas do not contain perennial flows, the presence of aquatic communities is likely limited. However, portions of the tributaries draining the Circle Cliffs and White Canyon areas may contain warmwater fish assemblages.

3.7.2 Plant Communities and Habitats

3.7.2.1 Piceance Basin

The Piceance Basin lies within the Colorado Plateau ecoregion. An ecoregion is an area in which ecosystems have a general similarity; an ecoregion is characterized by the spatial pattern and composition of biotic and abiotic features. Colorado ecoregions are described by Chapman et al. (2006) and are shown in Figure 3.7.2-1. The Colorado Plateau ecoregion is characterized by a rugged tableland of mesas, plateaus, mountains, and canyons, often with abrupt changes in local relief.

Within this ecoregion, the northern portion of the basin, primarily located in Rio Blanco County, is included in the Semiarid Benchlands and Canyonlands subregion. Broad benches and mesas in alternating areas of high and low relief support grassland, shrub, and woodland vegetation types. Escarpments, hillslopes, cuestas, alluvial fans, and narrow canyons are also characteristic of this region. A few isolated peaks also occur. Elevations range from 5,400 to 9,200 ft, with local relief up to 1,000 ft. Deep soils of fine sand support sagebrush steppe with warm-season grasses (i.e., galleta grass [*Pleuraphis jamesii*] and blue grama [*Bouteloua gracilis*]), as well as shrubs (primarily black sagebrush [*Artemisia nova*], winterfat [*krascheninnikovia lanata*], mormon tea [*Ephedra viridis*], fourwing saltbush [*Atriplex canescens*], and shadscale [*Atriplex confertifolia*]). Shallow stony soils support pinyon-juniper woodlands of two-needle pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*). Scattered woodlands of gambel oak (*Quercus gambelii*) occur at the higher elevations. Woodlands have expanded beyond their original range because of fire suppression and erosion. The average annual precipitation is about 10 to 18 in. in lower areas and 20 to 25 in. at the

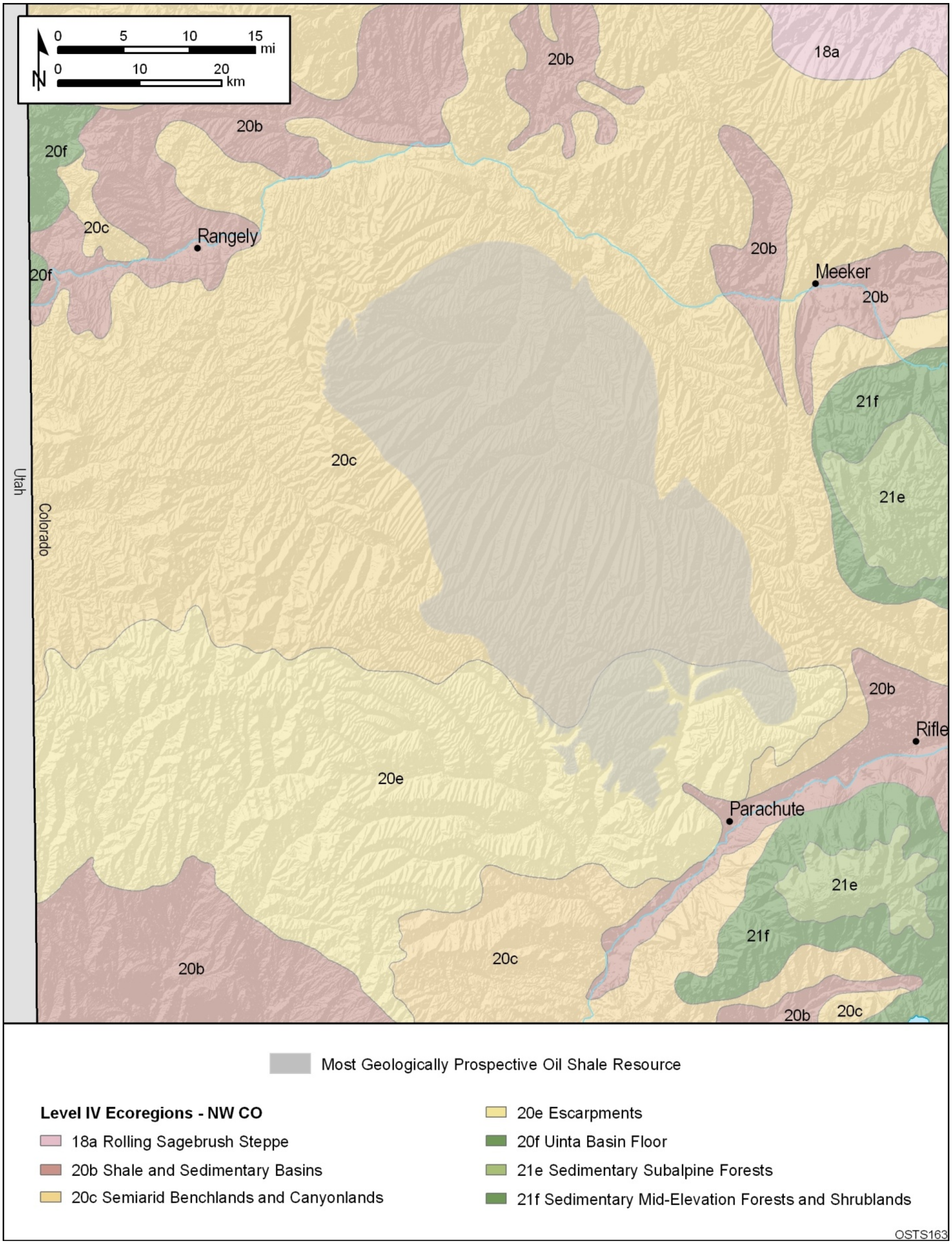

FIGURE 3.7.2-1 Ecoregions and Oil Shale Basin of Northwestern Colorado

highest elevations. This subregion has a moderate to long growing season with 60 to 120 mean annual frost-free days. Vegetation is generally not as sparse as in the drier ecoregions.

The southern portion of the Piceance Basin, in Garfield County, lies within the Escarpments subregion. Extensive cliff-bench complexes characterize this region and ascend to the forested mountain rim. High, deeply dissected cliffs, escarpments, and mesa tops are typical of this region. Elevations range from 6,000 to 9,000 ft, with local relief up to 3,000 ft. The Book Cliffs and Roan Cliffs are major scarp slopes in the region, and the region is prone to landslides. The average annual precipitation is 15 to 25 in., with up to 32 in. at higher elevations. This subregion has a short to moderate growing season with 60 to 90 mean annual frost-free days. Lower drier sites in the region support desert and semidesert grassland or shrubland, while steep, north-facing slopes at higher elevations support Douglas fir (*Pseudotsuga menziesii*) forest with mountain mahogany (*Cercocarpus* sp.) and aspen (*Populus* sp.). The predominant vegetation type of shallow soils on escarpments and benches is pinyon-juniper woodland. Mountain mahogany and aspen woodlands are additional vegetation types.

The majority of the Piceance Basin lies within the White River Resource Area. Pinyon-juniper woodland is the predominant vegetation community, composing 46% of the resource area and occurring at elevations from about 5,200 to 8,000 ft (BLM 1997a). Pinyon pine and Utah juniper are the dominant species; however, common juniper and one-seed juniper may also occur. This community is frequent on dry ridgetops with shallow soils. Utah juniper is dominant on drier sites, such as lower elevations and south or west exposures, while pinyon pine is dominant on locations with higher soil moisture. The canopy ranges from open to closed, with understory shrub and herbaceous vegetation density subsequently ranging from high to low. The sagebrush vegetation type composes 21% of the resource area and includes various sagebrush species with a mixed short-to-tall growth. The shrub density ranges from open to closed with a corresponding high-to-low density of understory species. Big sagebrush (*Artemisia tridentata*) is the dominant species below 7,000-ft elevations, and associates may include shadscale and winterfat. Herbaceous associates include squirreltail (*Elymus elymoides*), Indian ricegrass (*Achnatherum hymenoides*), Colorado wildrye (*Leymus ambiguus*), needle-and-thread (*Hesperostipa comata*), goldenweed (*Haplopappus* sp.), and scarlet globemallow (*Sphaeralcea coccinea*). Sagebrush communities at higher elevations typically include species associated with mountain shrub communities, including wheatgrasses (*Agropyron* spp.), bluegrasses (*Poa* spp.), needlegrasses (*Stipa* spp.), bromegrasses (*Bromus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), and penstemons (*Penstemon* spp.).

Mountain shrub communities include medium-sized to large tree-like shrubs. These communities generally occur at upper elevations on east, west, and north slopes. The shrub canopy is open to dense, with some areas of open canopy having the highest levels of herbaceous species production and diversity of any plant association in the resource area. This community type covers only 11% of the resource area; however, it covers 41% of the NOSR 1, which includes the southern portion of the Piceance Basin. Quaking aspen (*Populus tremuloides*) communities occur at elevations above 7,000 ft on northern to northeastern exposures. The canopy ranges from open to dense, with open stands having a higher production and diversity of grasses and forbs, and dense stands supporting a thick understory of woody species. Aspen communities occupy less than 5% of the resource area, but about 12% of the NOSR 1.

Greasewood shrub communities occur on drainage bottoms with poorly drained soils from 5,200 to 6,600 ft in elevation. Many drainages in the resource area, including the White River and Yellow Creek drainages, support extensive greasewood (*Sarcobatus vermiculatus*) stands. Dense stands have a sparse growth of short annual herbaceous species, while open stands include a mixture of other shrubs with perennial and annual grasses and forbs. Additional vegetation communities in the resource area include grasslands, saltbush–salt desert shrub, and gambel oak woodlands. Above 7,000 ft, coniferous forest and woodlands of blue spruce (*Picea pungens*), Engelmann spruce (*Picea engelmannii*), Douglas fir, or subalpine fir (*Abies lasiocarpa*) are present.

Barren areas of barren rock, rock outcrops, cliffs, talus slopes, and erosion pavements cover 9% of the resource area. These areas are sparsely vegetated or unvegetated and support many endemic and rare plant species. A number of species are endemic to semibarren outcrops of Green River shale, generally on soils of the Parachute Creek member of the Green River Formation, as well as the Uinta Formation (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 1993b, 2006i; Colorado Rare Plant Technical Committee 1999). These soils are generally shallow, dry, and fine textured with abundant white to light tan shale fragments on the surface. These oil-shale endemic species are adapted to the xeric and highly basic calcareous shale soils, which in some locations can be erosive, and often have a taproot and condensed growth habit. Plant communities at these locations can be varied and include open desert shrub, mixed desert shrub, or open pinyon-juniper communities (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006i; Colorado Rare Plant Technical Committee 1999). Many oil-shale endemics, such as the Dudley Bluffs twinpod (*Physaria obcordata*), Dudley Bluffs bladderpod (*Lesquerella congesta*), Parachute beardtongue (*Penstemon debilis*), and Piceance bladderpod (*Lesquerella parviflora*), have extremely limited distributions and are found only in the Piceance Basin (USFWS 1993b; Weber 1987). Others are also known from sites in Utah or Wyoming. Ephedra buckwheat (*Eriogonum ephedroides*) and dragon milk-vetch (*Astragalus lutosus*), for example, are endemic to Green River shale soils of the Piceance and Uinta Basins. These endemic species often occur as small scattered populations. Because of their small populations and vulnerability, many oil-shale endemics are federally listed, state-listed, or BLM sensitive species (Section 3.7.4). Some oil-shale endemics (e.g., dragon milk-vetch) have no official conservation status (UDWR 2006).

The southwestern portion of the Piceance Basin lies within the Grand Junction Resource Area. Arid grassland terraces in the resource area support galleta, cheatgrass (*Bromus tectorum*), saline wildrye (*Leymus salinus*), and broom snakeweed (*Gutierrezia sarothrae*) (BLM 1987a). A number of shrubland communities occur in the resource area. Saltbush communities on benches include shadscale, galleta, broom snakeweed, and cheatgrass. Dominant species on eroded land include Nuttall's saltbush (*Atriplex nuttallii*), shadscale, and saline wildrye. Greasewood communities on uplands include black greasewood, cheatgrass, and burr buttercup (*Ranunculus testiculatus*). Associates of black greasewood in washes include perfoliate pepperweed (*Lepidium perfoliatum*) and cheatgrass. Sagebrush communities in valleys include big sagebrush, cheatgrass, wheatgrasses, and bluegrasses. Associates of big sagebrush on mesas include black sagebrush, galleta, and blue grama; associates on highlands include columbia needlegrass (*Achnatherum nelsonii*), lupines (*Lupinus* sp.), and gambel oak. Blackbrush (*Coleogyne* *ramosissima*) communities on slopes and terraces include prickly pear (*Opuntia* sp.) and blue grama.

Pinyon-juniper woodland occurs in the Grand Junction Resource Area at elevations from 4,800 to 7,500 ft. Pinyon pine is dominant at the higher elevations within that range, while Utah juniper dominates at the lower elevations. Associated species on arid mesas include big sagebrush and black sagebrush; gambel oak and big sagebrush occur on mesic mesas. Associated species on arid slopes include galleta and true mountain mahogany (*Cercocarpus montanus*); true mountain mahogany and serviceberry (*Amelanchier* sp.) occur on mesic slopes. Douglas fir forest generally occurs on steep side slopes at elevations between 7,000 and 9,000 ft. Associates include snowberry (*Symphoricarpos* sp.) and serviceberry. Quaking aspen woodland occurs above 7,000 ft on soils with relatively high moisture, such as north and northeast facing slopes. Associates include mountain snowberry (*Symphoricarpos oreophilus*), elk sedge (*Carex geyeri*), and aspen pea-vine (*Lathyrus laetivirens*).

The southeastern corner of the Piceance Basin lies within the Glenwood Springs Resource Area. Pinyon-juniper woodland composes 39% of the public land in the resource area, with juniper predominating in the western portions (BLM 1988). Mountain shrub communities cover 20% of the resource area and are primarily composed of oakbrush and serviceberry and include mountain mahogany, bitterbrush (*Purshia tridentata*), willow (*Salix* sp.), and alder (*Alnus* sp.). Semidesert shrub communities compose 27% of the public land; however, this type occurs primarily on low elevations below the Roan Plateau. The dominant shrubs are sagebrush species, including big sagebrush, low sagebrush (*Artemisia arbuscula*), and black sagebrush, as well as other sagebrush species. Additional semidesert shrub species include black greasewood, winterfat, shadscale, mat (*Atriplex corrugata*), and fourwing saltbush, as well as other saltbush species, and rabbitbrush (*Chrysothamnus* sp.). Aspen stands, conifer forest, and grassland habitat compose smaller portions of the resource area. Aspen is a short-lived, fast-growing, pioneer species that is eventually replaced by shade-tolerant conifers such as Engelmann spruce or subalpine fir. Harvesting promotes the perpetuation of aspen stands by stimulating root sprouting and regrowth. Conifer forest includes Douglas fir forest and Engelmann spruce-subalpine fir forest. Forest management promotes a balanced age class distribution that includes stands of all ages.

Noxious and invasive weeds can adversely affect native ecosystems. These aggressive, exotic plant species often displace native plants, thereby altering the species composition and community structure of native plant communities (BLM 2006a). They can contribute to increased soil erosion, reduced species diversity and structural diversity, and loss of habitat. The following noxious and problem weed species occur in the Piceance Basin: leafy spurge (*Euphorbia esula*); houndstongue (*Cynoglossum officinale*); knapweeds—Russian, spotted, and diffuse (*Acroptilon repens*, *Centaurea stoebe*, and *C. diffusa*); musk thistle (*Carduus nutans*); Canada thistle (*Cirsium arvense*); yellow toadflax (*Linaria vulgaris*); whitetop/hoary cress (*Cardaria draba*); bluebur stickseed (*Lappula redowski*); cheatgrass; and tall whitetop/perennial pepperweed (*Lepidium latifolium*).

The Duck Creek ACEC (3,430 acres), Ryan Gulch ACEC (1,440 acres), and Dudley Bluffs ACEC (1,630 acres) are located in the northern portion of the Piceance Basin

(Figure 3.1.1-2). These ACECs include several federally listed threatened and candidate plant species, state rare species, sensitive species, and remnant vegetation associations. Additional ACECs are located outside of the most geologically prospective area. Upper Greasewood Creek (in two units), Lower Greasewood Creek, and Yanks Gulch ACECs are located near the northern boundary of the basin and south of the White River. The White River Riparian ACEC is composed of numerous small blocks along the river, north of the basin and continuing downstream. Coal Draw, South Cathedral Bluff, and East Douglas Creek ACECs are also located near the basin to the west, and Deer Gulch, Magpie Gulch, and Anvil Points are near the eastern boundary. (The Lower Colorado River Cooperative Management Area ACEC, located downstream of the basin to the south, is designated for the protection of riparian and wildlife values [BLM 1988].)

Two ACECs occur in the southeastern portion of the Piceance Basin. The Eastfork Parachute Creek ACEC includes three rare plants: the hanging garden sullivantia (*Sullivantia hapemanii* var. *purpusii*), Utah fescue (*Festuca dasyclada*), and southwest stickleaf (*Mentzelia argillosa*) (BLM 2006a). In addition, three rare plant communities occur in the ACEC. The montane riparian forest is predominantly composed of Colorado blue spruce and redosier dogwood (*Cornus sericea*). The boxelder riparian forest is primarily composed of boxelder (*Acer negundo*), narrowleaf cottonwood (*Populus angustifolia*), and redosier dogwood. The western slope grassland community, which occurs on south-facing slopes of shale or mudstone soils, is a shale barrens dominated by Indian ricegrass. The Trapper/Northwater Creek ACEC includes two rare plants: hanging garden sullivantia and Utah fescue. Two rare plant communities also occur in this ACEC: sagebrush bottomland shrubland and western slope grassland.

Riparian vegetation communities occur along rivers, perennial and intermittent streams, lakes, and reservoirs, and at springs (BLM 1987a, 1988). These communities generally form a vegetation zone along the margin or in the stream channel of upper drainages, distinct from the adjacent upland area in species composition and density. Riparian communities are dependent on the streamflows or reservoir levels and are strongly influenced by the hydrologic regime, which affects the frequency, depth, and duration of flooding or soil saturation. Peak flows on major streams generally occur in May and June as a result of snowmelt, with low flows in winter. Peak flows on smaller streams are often due to summer thunderstorms. Intermittent streams generally intersect the water table and have seasonal flow from groundwater discharge at seeps and springs, or they may have a surface water source. Ephemeral streams are directly dependent on precipitation, having a water table located below the soil surface, and having flow only during spring runoff and following intense summer storms (BLM 1997a). Ephemeral streams often do not support riparian vegetation.

Wetland areas are typically inundated or have saturated soils for a portion of the growing season, and support plant communities that are adapted to saturated soil conditions. Unvegetated wetlands include mudflats, gravel beaches, and rocky shores (Cowardin et al. 1979). Riparian communities may include wetlands; however, the upper margins of riparian zones may be only infrequently inundated. Wetlands are generally associated with perennial water sources, such as springs, perennial segments of streams, or lakes and ponds. Functions of riparian and wetland areas include (1) erosion reduction and water quality improvement by dissipation of stream energy associated with high flows; (2) filtration of sediments and promotion of floodplain development; (3) improvement of floodwater retention and groundwater recharge of alluvial aquifers; (4) stabilization of stream banks by rootmass development; (5) provision of habitat, water depth, duration, and temperature for fish production, waterfowl breeding, and other wildlife uses by development of diverse ponding and channel characteristics; and (6) support of greater biodiversity (BLM 1997a).

Moist meadow wetlands occur at the headwaters of drainages on the Roan Plateau (BLM 2006a). These wetlands are dominated by herbaceous species. Riparian shrub communities occur along the bottoms of major drainages. These communities include willow (*Salix* sp.), elderberry (*Sambucus* sp.), gooseberry (*Ribes* sp.), and riparian grasses. Lower reaches of the main drainages on the plateau support a narrow zone of coniferous woodland, composed primarily of blue spruce and Engelmann spruce with interspersed shrubs. A number of streams on the plateau support deciduous woodlands along their margins. These woodlands are composed of narrowleaf cottonwood, boxelder, and shrubs. Hanging gardens occur along canyon walls, predominantly north-facing walls where Green River shale beds are exposed, where seeps provide consistent moisture throughout the year.

In the Grand Junction Resource Area, nonwooded riparian areas support saltcedar (*Tamarix* sp.), saltgrass (*Distichlis spicata*), rush (*Juncus* sp.), and bulrush (*Scirpus* sp.). Species of wooded riparian areas include cottonwood, boxelder, skunkbrush (*Rhus trilobata*), and willow (BLM 1987a). Along some rivers, fire has resulted in the removal of some Fremont cottonwood (*Populus fremontii*) stands greater than the rate of replacement. Overgrazing has impacted many riparian areas. Riparian and wetland habitats in the Glenwood Springs Resource Area include grassland with sedge (*Carex* sp.) and rush species (BLM 1988). Riparian habitats in this resource area also support cottonwood and willow, along with associated grasses and forbs. In this resource area, riparian habitats have been greatly impacted by such factors as road construction, gravel extraction, water diversions, and livestock grazing.

3.7.2.2 Uinta Basin

The Uinta Basin lies within the Colorado Plateau ecoregion. Ecoregions in Utah are described by Woods et al. (2001). The Colorado Plateau ecoregion is characterized by a dissected tableland of benches, buttes, mesas, plateaus, salt valleys, cliffs, and canyons (Figures 3.7.2-2 and 3.7.2-3).

Within this ecoregion, the Uinta Basin Floor subregion includes much of Uintah County and portions of Duchesne County. This region lies in a large, arid, synclinal basin with alluvial terraces, outwash terraces, floodplains, hills, and ridges; in some areas, mesas and benches alternate with lower arable land. Elevations mostly range from 4,300 to 6,400 ft, with local relief up to 1,200 ft. The basin receives a large amount of stream runoff from the adjacent mountains. The average annual precipitation is about 5 to 8 in., and the growing season is moderate to long, with 115 to 140 mean annual frost-free days. Vegetation is predominantly a saltbush-greasewood association with shadscale, Wyoming big sagebrush, fourwing saltbush, winterfat, Indian ricegrass, galleta, and needle-and-thread; black sagebrush may also be present.

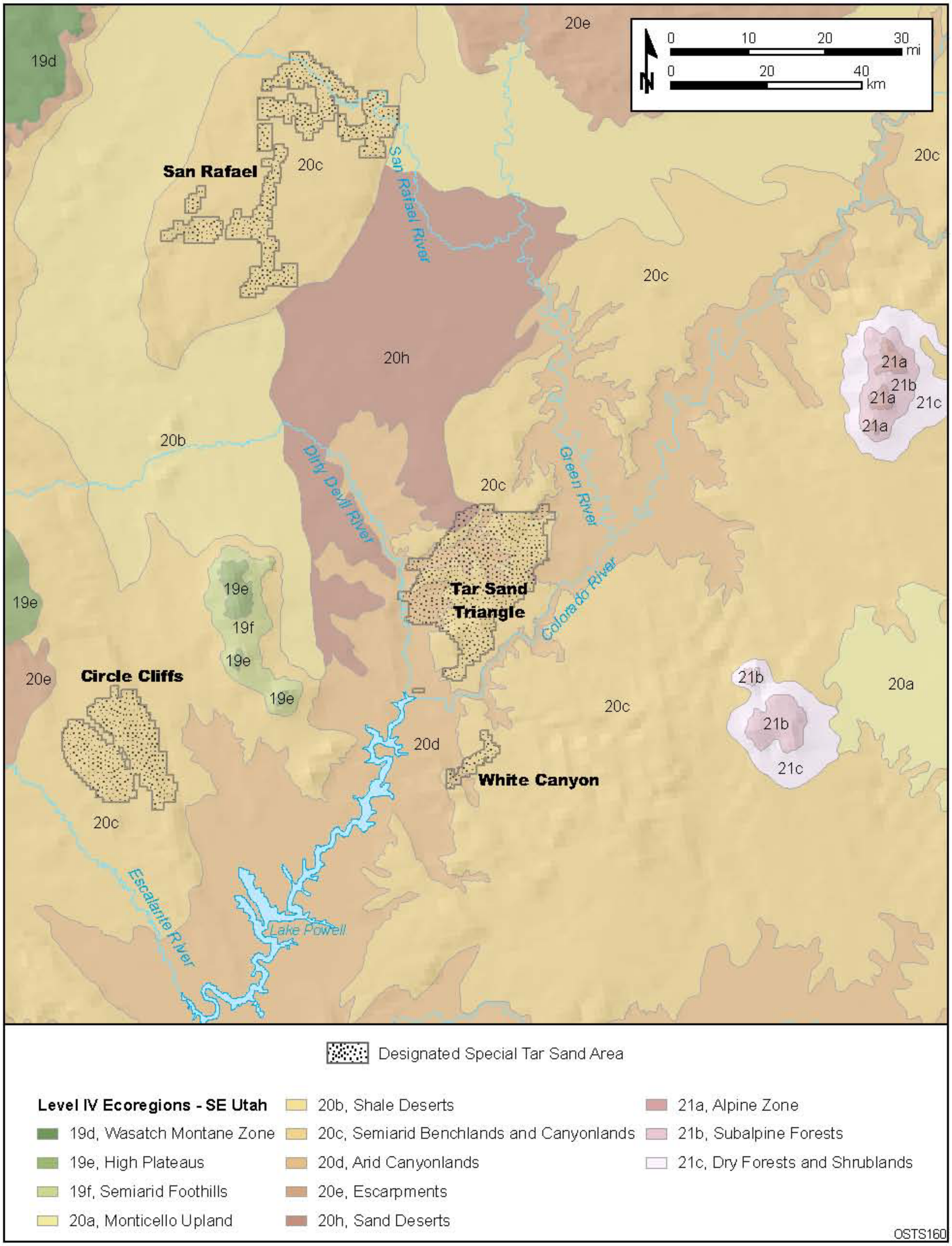

FIGURE 3.7.2-2 Ecoregions and Special Tar Sand Areas of Southeastern Utah

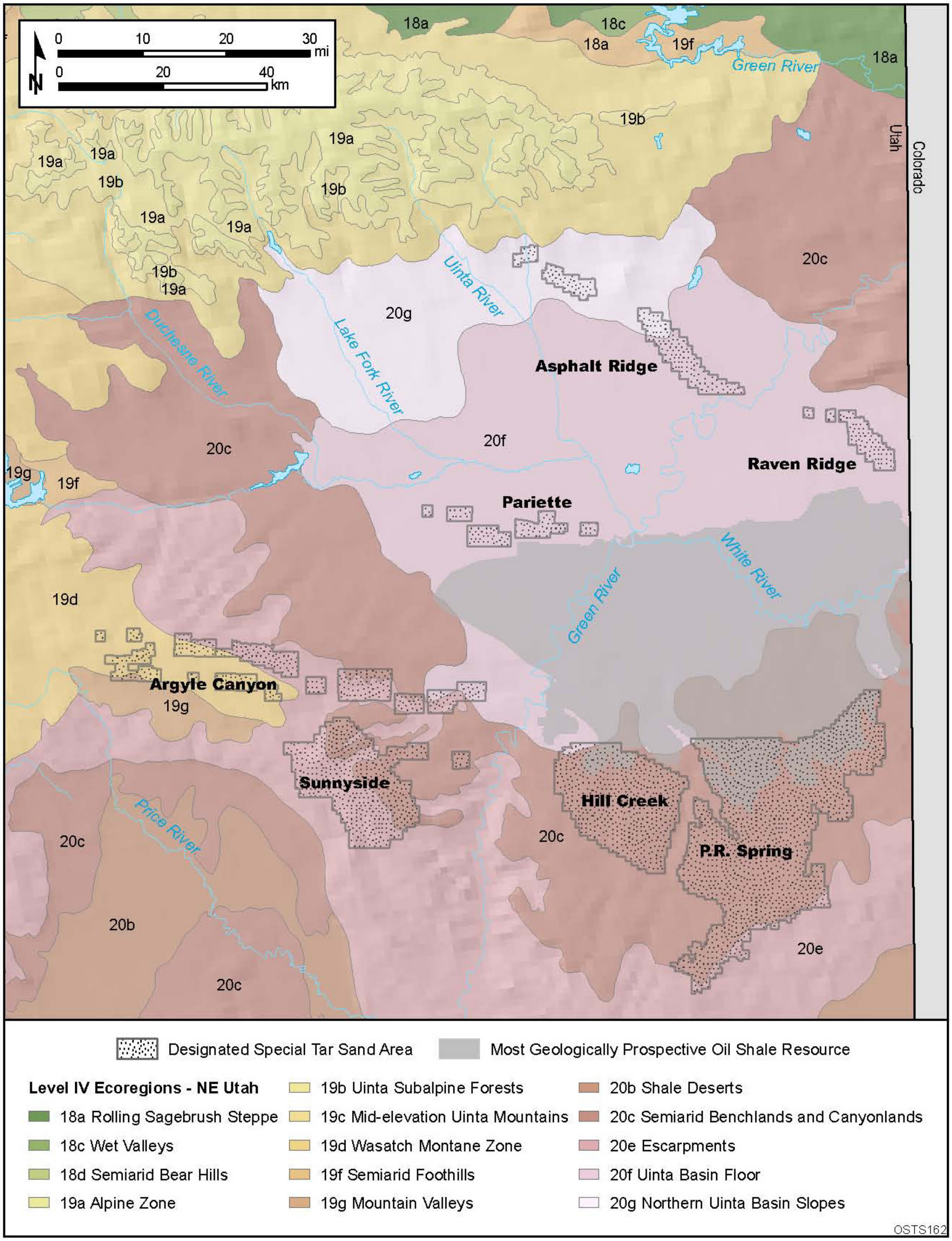

FIGURE 3.7.2-3 Ecoregions and Special Tar Sand Areas of Northeastern Utah

The Semiarid Benchlands and Canyonlands subregion includes portions of Uintah, Duchesne, and Carbon Counties. Broad benches and mesas in alternating areas of high and low relief support grassland, shrub, and woodland vegetation types. Escarpments, hillslopes, cuestas, alluvial fans, and narrow canyons are also characteristic of this region. Elevations mostly range from 5,000 to 7,500 ft, with local relief up to 2,000 ft. A few isolated peaks of higher elevation also occur. Bare rock is common. Deep soils of fine sand over most of the region support sagebrush steppe with warm-season grasses (i.e., galleta grass and blue grama) and shrubs (primarily black sagebrush, big sagebrush, blackbrush, winterfat, mormon tea, and fourwing saltbush). Shallow stony soils support pinyon-juniper woodlands of two-needle pinyon pine and Utah juniper. Sage parkland or mountain brush occurs on higher elevations. Woodlands have expanded beyond their original range because of fire suppression and erosion. The average annual precipitation is about 8 to 14 in. in lower areas and 20 to 25 in. at the highest elevations. This subregion generally has a moderate to long growing season with 80 to 160 mean annual frost-free days, but less than 50 days on the highest areas. Vegetation is generally not as sparse as in the drier ecoregions.

A number of species are endemic to the Green River shale barrens, generally on soils of the Evacuation Creek or Parachute Creek member of the Green River Formation, as well as the Uinta Formation (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006i). These soils are generally shallow, dry, and fine textured with abundant white to light tan shale fragments on the surface. These oil-shale endemic species are adapted to the xeric and highly basic calcareous shale soils, which in some locations can be erosive, and often have a taproot and condensed growth habit. Plant communities at these locations can be varied and include open desert shrub, mixed desert shrub, or open pinyon-juniper communities (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006i). Occurrences of these endemics are often located within a narrow band along the southern margin of the Uinta Basin. Many oil-shale endemics, such as the shrubby reed-mustard (*Schoenocrambe suffrutescens*), have extremely limited distributions and are found only in the Uinta Basin in Utah (UDWR 2006). Graham's beardtongue (*Penstemon grahamii*) and White River beardtongue (*Penstemon scariosus albifluvis*) also occur only in the Uinta Basin, primarily in Utah, with some sites in immediately adjacent Colorado. Others are also known from oil shale basins in Colorado or Wyoming. Ephedra buckwheat (*Eriogonum ephedroides*) and dragon milk-vetch (*Astragalus lutosus*), for example, are endemic to Green River shale soils in the Piceance and Uinta Basins. These endemic species often occur as small scattered populations. Because of their small populations and vulnerability, many oil-shale endemic species are federally listed, state-listed, or BLM sensitive species (Section 3.7.4). Some oil-shale endemics have no official conservation status, such as dragon milk-vetch, fragrant cryptantha (*Cryptantha grahamii*), Barneby's columbine (*Aquilegia barnebyi*), Barneby's thistle (*Cirsium barnebyi*), and Barneby's cryptantha (*Cryptantha barnebyi*) (UDWR 2006).

Large areas of the Uinta Basin lie within the Uinta Basin Floor subregion of the Colorado Plateau ecoregion. Streams have high levels of dissolved solids and suspended sediments. Riparian areas support cottonwood trees and Russian olive (*Elaeagnus angustifolia*), an invasive exotic tree (Woods et al. 2001).

The Pariette Wetlands ACEC lies in the northwestern portion of the Uinta Basin. This ACEC is also adjoined with the Lower Green River ACEC, which includes riparian habitat and special status animal species. The Nine Mile ACEC is located at the southwestern margin of the basin and is also adjoined by the Lower Green River ACEC. The Raven Ridge-Addition ACEC is located in Colorado near the northeastern boundary of the basin. This ACEC is designated for the protection of federally listed plant species.

3.7.2.3 Green River and Washakie Basins

The Green River Basin lies within the Wyoming Basin ecoregion. Ecoregions in Wyoming are described by Chapman et al. (2004). The Wyoming Basin ecoregion occupies a broad arid basin with scattered hills and low mountains (Figure 3.7.2-4). The climate in the basin is influenced by the surrounding mountain ranges. The predominant vegetation types are grasslands and shrublands. The Rolling Sagebrush Steppe subregion is the predominant subregion within the Green River Basin, with large areas of the Salt Desert Shrub Basins subregion scattered throughout much of the basin. In addition, the Foothill Shrublands and Low Mountains subregion occurs in the southern and eastern portions of the basin. This region is characterized by isolated, dry mountain ranges and foothill slopes and includes alluvial fans, hills, ridges, and valleys. Elevations in foothills range from 5,000 to 7,000 ft, and more than 9,000 ft in some mountain ranges. Local relief can be up to 800 ft. The average annual precipitation is about 14 to 20 in., and the growing season is short to moderate with 75 to 100 mean annual frost-free days. Fine-textured soils occur at lower elevations and primarily support sagebrush steppe and grassland with big sagebrush, rabbitbrush (*Chrysothamnus* sp.), prickly pear, bluebunch wheatgrass (*Pseudoroegneria spicata*), and Idaho fescue (*Festuca idahoensis*), while rocky outcrops support woodlands of Rocky Mountain juniper (*Juniperus scopulorum*), Utah juniper, and mountain mahogany. Higher elevations support Rocky Mountain juniper, lodgepole pine (*Pinus contorta*), limber pine (*Pinus flexilis*), aspen, Douglas fir, and ponderosa pine (*Pinus ponderosa*) forests.

The Washakie Basin lies within the Wyoming Basin ecoregion. The Rolling Sagebrush Steppe is the predominant subregion within the Washakie Basin. This subregion is a wide semiarid area of rolling plains with hills, mesas, cuestas, and nearly level floodplains and terraces. Footslopes, ridges, rolling alluvial fans, and outwash fans occur near the mountains. The average annual precipitation is 6 to 16 in., with a moderate growing season with 75 to 100 mean annual frost-free days. Elevations range from 4,900 to 7,200 ft. Local relief can be up to 400 ft. Sagebrush steppe shrubland is the predominant vegetation type, with mixed grass prairie predominating in the far eastern portions. The dominant shrub species is Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Silver (*Artemisia cana*) and black sagebrush occur in the lowlands, and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) occurs at higher elevations. Associated species of Wyoming big sagebrush include western wheatgrass (*Pascopyrum smithii*), needle-and-thread, blue grama, Sandberg bluegrass (*Poa secunda*), junegrass (*Koeleria macrantha*), rabbitbrush, and fringed sage (*Artemisia frigida*).

The sagebrush steppe has been affected by frequent fires and in some areas has been replaced by European annual grasses. Smaller areas of the Salt Desert Shrub Basins subregion

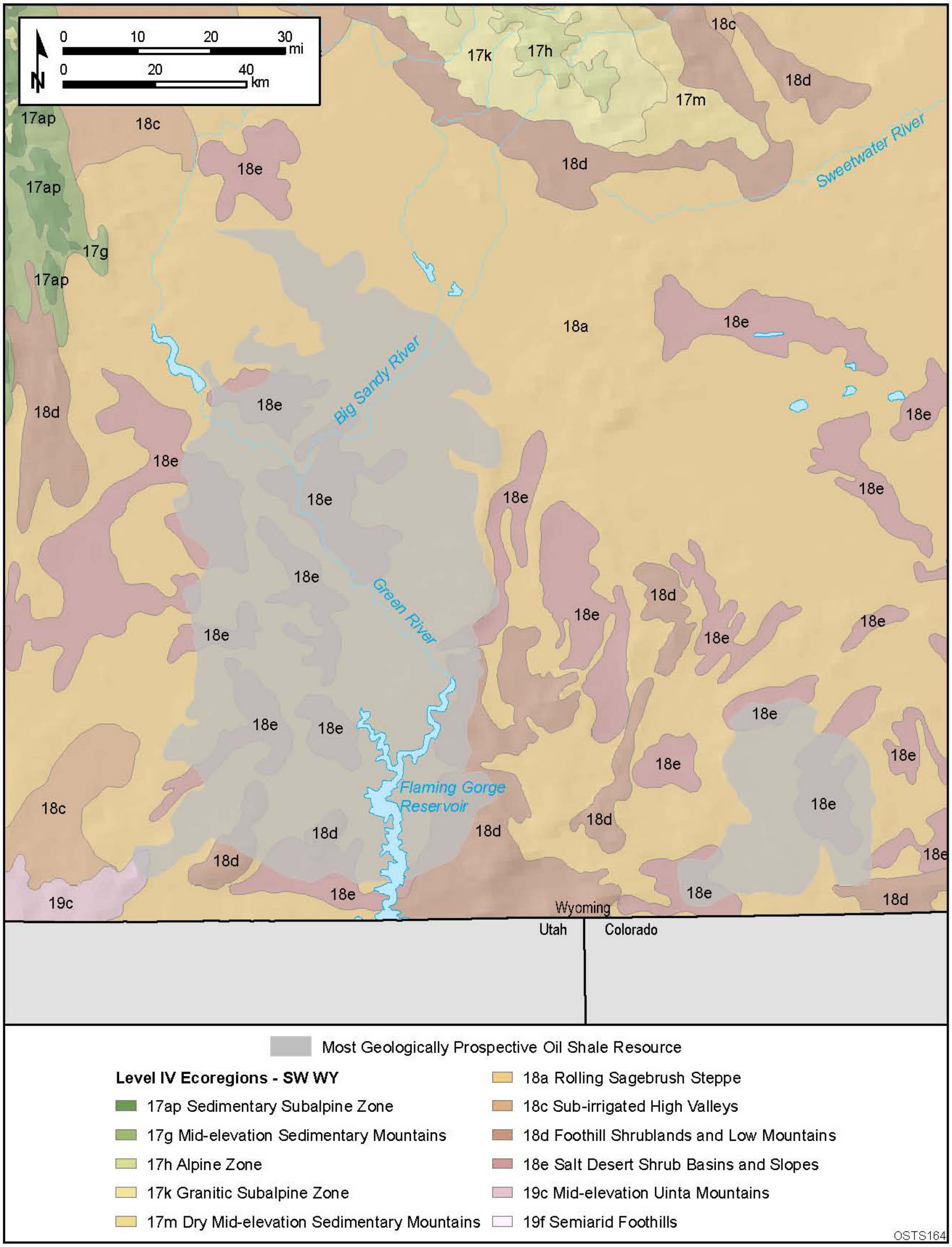

FIGURE 3.7.2-4 Ecoregions and Oil Shale Basins of Southwestern Wyoming

are scattered throughout the Washakie Basin. This arid plains subregion is characterized by disjunct playas and sand dunes, nearly level floodplains and terraces, and rolling alluvial fans. Elevations range from 5,800 to 7,200 ft. The average annual precipitation is 6 to 10 in., with a moderate growing season with 75 to 100 mean annual frost-free days. Soils are more alkaline and less permeable than in the Rolling Sagebrush Steppe. Vegetation is sparse, consisting of desert shrublands with alkaline-tolerant shrubs and grasses. Shrubs include shadscale, greasewood, Gardner saltbush (*Atriplex gardneri*), bud sage (*Picrothamnus desertorum*), and big sagebrush. Stabilized sand dunes, which have greater moisture, higher permeability, and lower alkalinity, support a higher diversity of plant species, primarily alkali cordgrass (*Spartina gracilis*), indian ricegrass, blowout grass (*Redfieldia flexuosa*), alkali wildrye (*Leymus simplex*), and needle-and-thread. Non-native species, such as Russian thistle (*Salsola tragus*), cheatgrass, and halogeton (*Halogeton glomeratus*), may become established as a result of grazing pressure.

A number of species are endemic to semibarren shale outcrops, generally on soils derived from the Green River Formation (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; University of Wyoming 2006). These soils are generally thin, dry, and fine textured with abundant white to light tan shale fragments on the surface. These oil-shale endemic species are adapted to the xeric and highly basic calcareous shale soils, which in some locations can be erosive, and often have a taproot and condensed growth habit. Plant communities at these locations can be varied and include open desert shrub, mixed desert shrub, or open pinyon-juniper communities (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; University of Wyoming 2006). Many oil-shale endemics have extremely limited distributions. For example, tufted twinpod (*Physaria condensata*) is found only in the Green River Basin (University of Wyoming 2006). Others are also known from oil shale basins in Colorado or Utah. Rollins' cat's-eye (*Cryptantha rollinsii*), for example, is endemic to Green River shale soils in the Washakie, Green River, Piceance, and Uinta Basins. These endemic species often occur as small scattered populations. Because of their small populations and vulnerability, many oil-shale endemics are federally listed, state-listed, or BLM sensitive species (Section 3.7.4).

Large areas of the Green River and Washakie Basins lie within the Rolling Sagebrush Steppe subregion of the Wyoming Basin ecoregion. Within this subregion, streams and rivers with mountain headwaters have a moderate gradient with granite or limestone cobble substrates (Chapman et al. 2004). Streams with headwaters in the Wyoming Basin center have a low gradient with finer gravel substrates of shales and are more incised. Small streams in the subregion are weakly intermittent or ephemeral, with substrates of sand or platy shale. Within the Salt Desert Shrub Basins subregion, streams are ephemeral or weakly intermittent; many are incised and flow into playas, which are seasonal with high levels of soluble salts (Chapman et al. 2004). Substrate is typically fine-textured or platy shale gravels. Within the Foothill Shrublands and Low Mountains subregion, streams originate in the nearby Rocky Mountains or are spring-fed streams originating on the higher ranges of the basin (Chapman et al. 2004). They generally have a steep gradient with riffle/run habitats and plunge pools. Streams generally have limestone or granite cobble or boulder substrates.

In the sand dunes area on the northeastern corner of the Green River Basin, ephemeral ponds fed by meltwater flockets are ecologically important wetlands because of their early season production of invertebrates and nesting habitat for waterfowl (BLM 2004d). In the northeastern corner of the Green River Basin, seeps and springs occur within the Jack Morrow Hills Planning Area (BLM 2004d).

Wetlands associated with high levels of soil moisture in typically arid areas support herbaceous species such as Baltic rush (*Juncus arcticus* ssp. *littoralis*), Nebraska sedge (*Carexnebrascensis*), water sedge (*Carex aquatilis*), and tufted hairgrass (*Deschampsia caespitosa*), with occasional species along the margin, including mountain iris (*Iris missouriensis*), sandbar willow (*Salix interior*), and narrowleaf cottonwood (BLM 2008c). Areas that are seasonally wet include Kentucky bluegrass (*Poa pratensis*), tufted hairgrass, foxtail barley (*Herdeum jubatum*), redtop (*Agrostis gigantea*), northern reedgrass (*Calamagrostis stricta* ssp. *inexpansa*), slender wheatgrass (*Elymus trachycaulus*), basin wildrye (*Leymus cinereus*), field horsetail (*Equisetum arvense*), wood rose (*Rosa woodsii*), shrubby cinquefoil (*Dasiphora fruticosa* ssp. *floribunda*), silver sage, basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), greasewood, and willows. Ephemeral washes may support a community of salt-tolerant herbaceous species, including inland saltgrass and western wheatgrass, along with greasewood and basin big sagebrush. Riparian areas often consist of a lower zone of sedges and willows, where soil is saturated more frequently, and an upper zone of silver sagebrush with basin wildrye, Kentucky bluegrass, streambank wheatgrass (*Elymus lanceolatus* ssp. *lanceolatus*), redtop, Baltic rush, clover (*Trifolium* sp.), checkermallow (*Sidalcea* sp.), aster (*Aster* sp.), and, in some areas, cottonwood and willow.

Basin big sagebrush is found as a dominant species along valley bottoms, canyons, and ephemeral streams. Greasewood shrublands occur along playas, desert lakes, ponds, and desert streams, often on terraces above wetter areas of silver sagebrush or basin big sagebrush. Associated species typically include shadscale, Gardner saltbush, alkali sagebrush (*Artemisia arbuscula* ssp. *longiloba*), basin big sagebrush, inland saltgrass, western wheatgrass, alkali sacaton (*Sporobolus airoides*), bottlebrush squirreltail, Sandberg bluegrass, biscuitroot (*Lomatium* sp.), pepperweed (*Lepidium* sp.), and sea blight (*Suaeda moquinii*).

Wetland and riparian areas generally are herbaceous wetlands, herbaceous riparian areas, and shrub-dominated riparian areas. Sedges, rushes, cattails (*Typha* spp.), and willows dominate wetter areas. In addition to margins of streams and bodies of open water, wetlands occur as open meadows that collect moisture in winter and spring. Many wetland areas are seasonally dry and infrequently inundated. Alkaline conditions can occur in areas of limited drainage. Riparian areas along major streams on nonirrigated, nonfederal land support woodlands of plains cottonwood (*Populus deltoides* ssp. *monilifern*), narrowleaf cottonwood, Fremont cottonwood, Geyer willow (*Salix geyeriana*), sandbar willow, and yellow willow (*Salix lutea*). Areas of shallow soil along the riparian margin or in rocky areas support predominantly herbaceous communities composed of riparian woodland understory species such as slender wheatgrass, thickspike wheatgrass (*Elymus lanceolatus*), smooth brome (*Bromus inermis*), tufted hairgrass, meadow foxtail (*Alopecurus* sp.), timothy (*Phleum pratense*), mountain iris, horsetail, gooseberry, currant (*Ribes* sp.), buffaloberry (*Shepherdia* sp.), and basin big sagebrush. Riparian habitats in foothills and mountain areas generally have high moisture levels throughout the growing season. The dominant species are generally willows with an understory of sedges, rushes, spikerush

(*Eleocharis* sp.), and grasses. Open meadows and marshes support communities composed of these understory species.

Within the Green River Basin, the Greater Red Creek ACEC, composed of 131,890 acres located in the southeastern corner of the basin, is intended to protect unique ecological features, including Colorado River cutthroat trout (BLM 1997b). This ACEC includes the watersheds of Sage Creek and Currant Creek, which are tributaries of Red Creek. Management objectives include improving riparian habitats to achieve proper functioning condition throughout the ACEC, and improving watershed condition to improve channel stability, vegetation diversity, vegetation abundance, and water quality. The Special Status (Candidate) Plant Species ACEC, consisting of 900 acres on 58 sites, a number of which are located in the southwestern corner of the Green River Basin, is intended to protect populations of four plant species — Fremont County rockcress (*Arabis pusilla*), precocious milk-vetch (*Astragalus proimanthus*), mountain tansymustard (*Descurainia torulosa*), and hairy greenthread (*Thelesperma pubescens*) (BLM 1997b). Management objectives include preventing the destruction or loss of the plant communities and important habitat supporting the special status species, enhancing or expanding such habitat, and providing sufficient protection to the species to prevent their listing as threatened or endangered.

One location of the Special Status (Candidate) Plant Species ACEC occurs near the northwestern boundary of the Washakie Basin. In addition, the Hells Canyon ACEC in Moffat County, Colorado, is located approximately 5 km (3 mi) south of the Washakie Basin.

In 2009, the WGFD revised its 2001 Strategic Habitat Plan (SHP) to help guide collaboration and planning efforts regarding strategies to meet the challenges of habitat conservation in the face of forces such as energy development, climate change, invasive species, and drought. The 2009 SHP establishes "priority (crucial habitat) areas" and "enhancement areas" across Wyoming that are considered crucial for conserving populations of terrestrial and aquatic wildlife now and into the future, and areas that should be targeted for improvement over the next few years as resources and partnerships allow. Many of these terrestrial and aquatic habitat priority and enhancement (and combination) areas overlap the area in Wyoming available for application for leasing for oil shale development under one or more of the proposed alternatives (see Tables 1, 2, and 3 in text box).

3.7.2.4 Special Tar Sand Areas

A large number of plant communities are present in the STSAs and vary considerably according to moisture availability and elevation. Even within individual STSAs, a wide range of habitats may occur. Rare plant communities, such as remnant vegetation associations, and rare or endemic plant species occur near the STSAs, and potentially within them. The canyonlands area, which includes the three southernmost STSAs (San Rafael, Tar Sand Triangle, and White Canyon), contains a particularly large number of endemic plant species (BLM 1984b).

Table 1 WGFD Strategic Habitat Plan Aquatic Habitat Priority/Enhancement Areas That Overlap BLM Allocations for Lands Available in Wyoming for Application for Commercial Leasing for Oil Shale Development

Basin	2009 SHP Area	Designation
Green River Basin	Lower Big Sandy Corridor	Enhancement
Green River Basin	Green River–Seedskadee Reach	Enhancement
Green River Basin	Green River–Town Reach	Enhancement
Green River Basin	Lower Blacks Fork Corridor	Enhancement
Green River Basin	Little Mountain	Enhancement
Green River Basin	Ringdahl	Crucial
Green River Basin	Sage Creek	Crucial

Source: WGFD (2012).

Table 2 WGFD Strategic Habitat Plan Terrestrial Habitat Priority/Enhancement Areas That Overlap BLM Allocations for Lands Available in Wyoming for Application for Commercial Leasing for Oil Shale Development

Basin	2009 SHP Area	Designation
Green River Basin	Big Sandy	Crucial
Green River Basin	Mesa-Jonah	Crucial
Green River Basin	East Labarge	Crucial
Green River Basin	Sands	Crucial
Green River Basin	Pilot Butte	Enhancement
Green River Basin	Fontenelle	Crucial
Green River Basin	South Labarge/Siate Creek	Enhancement
Green River/Washakie Basins	South Rock Springs	Enhancement
Green River Basin	Uinta	Crucial
Green River Basin	Uinta/Cedar Mountain	Enhancement
Washakie Basin	Sierra Madre	Crucial
Washakie Basin	Baggs	Enhancement

Source: WGFD (2012).

Table 3 WGFD Strategic Habitat Plan Combination Habitat Priority/Enhancement Areas That Overlap BLM Allocations for Lands Available in Wyoming for Application for Commercial Leasing for Oil Shale Development

Basin	2009 SHP Area	Designation
Green River Basin	Green River/Blacks Forks/Hams Fork	Crucial
Green River Basin	Flaming Gorge	Crucial
Washakie Basin	Red Desert/Bitter Creek	Crucial

Source: WGFD (2012).

The STSAs lie primarily within the Colorado Plateau ecoregion; however, most of the Argyle Canyon STSA and a small portion of the Sunnyside TSA lie within the Wasatch and Uinta Mountains ecoregion.

- The Argyle Canyon STSA is primarily located in the Wasatch Montane Zone subregion of the Wasatch and Uinta Mountains ecoregion, with a small portion in the Mountain Valleys subregion of that ecoregion. The Escarpments subregion of the Colorado Plateau ecoregion intersects a small portion of the northeastern corner of the STSA.

- The Asphalt Ridge STSA is located in the Uinta Basin Floor and North Uinta Basin Slopes subregions of the Colorado Plateau ecoregion.

- The Hill Creek STSA is located entirely in the Semiarid Benchlands and Canyonlands subregion of the Colorado Plateau ecoregion.

- The Pariette STSA is located entirely in the Uinta Basin Floor subregion.

- The P.R. Spring STSA is located primarily in the Semiarid Benchlands and Canyonlands subregion, with a small portion in the Escarpments subregion of the Colorado Plateau ecoregion.

- The Raven Ridge STSA is located entirely in the Uinta Basin Floor subregion.

- The San Rafael STSA is located entirely in the Semiarid Benchlands and Canyonlands subregion.

- The Sunnyside STSA is located primarily in the Escarpments and Semiarid Benchlands and Canyonlands subregions, with the northeastern corner intersecting the Uinta Basin Floor subregion. The Wasatch Montane Zone crosses the northwestern portion of the STSA.

- The Tar Sand Triangle STSA is located mostly in the Semiarid Benchlands and Canyonlands subregion, with smaller portions in the Arid Canyonlands and Sand Deserts subregions.

- The White Canyon STSA is located mostly in the Semiarid Benchlands and Canyonlands subregion, with a smaller portion in the Arid Canyonlands subregion.

The Colorado Plateau ecoregion includes the following subregions: Semiarid Benchlands and Canyonlands, Arid Canyonlands, Escarpments, Uinta Basin Floor, North Uinta Basin Slopes, and Sand Deserts. Utah ecoregion descriptions are from Woods et al. (2001).

The Semiarid Benchlands and Canyonlands subregion includes all or portions of six STSAs, more than any other subregion. It includes pinyon-juniper woodland, with pinyon pine and Utah juniper, on shallow or stony soils, grassland, big sagebrush and black sagebrush shrubland, with sage parkland and mountain brush at the higher elevations. Additional species include winterfat, Mormon tea, fourwing saltbush, blackbrush, and warm-season grasses such as galleta and blue grama. Areas of unvegetated or sparsely vegetated exposed bedrock are common. Annual precipitation is generally 8 to 14 in., with 20 to 25 in. at the upper elevations. The mean number of frost-free days is mostly 80 to 160, with less than 50 at higher elevations.

The Arid Canyonlands subregion contains the inner gorge of the Colorado River and tributaries. Annual precipitation is only 5 to 8 in. Plant communities include blackbrush and saltbush-greasewood shrublands. Additional species include shadscale, galleta, indian ricegrass, fourwing saltbush, blue grama, mat saltbush, sand dropseed, sand sagebrush, and bud sagebrush. Blackbrush is common in deep canyons, and tamarisk, an invasive species, forms extensive stands in riparian zones in some areas. The mean number of frost-free days is 160 to 220 or more, and winters are mild.

The Escarpments subregion includes a wide range of habitats and elevation gradients with steep slopes. Scrubland, woodland, and Douglas fir forest are the predominant habitat types. Douglas fir forest occurs on northern upper elevation slopes. Desert and semidesert grassland and shrubland occur at low elevations. Pinyon-juniper woodland is often a dominant habitat on shallow soils. Additional habitats include high-elevation forests of Engelmann spruce, subalpine fir, Douglas fir, and Arizona pine forest, and mountain mahogany/oak scrub. Annual precipitation ranges from 8 to 30 in. The mean number of frost-free days is 40 to 150.

The Uinta Basin Floor subregion is arid, with only 5 to 8 in. of annual precipitation. The predominant habitat type is saltbush-greasewood shrubsteppe. Additional species present include grasses (indian ricegrass, galleta, and needle-and-thread) and shrubs (shadscale, Wyoming big sagebrush, four-wing saltbush, winterfat, and black sagebrush). This subregion receives abundant streamflows from the adjacent mountains. Common species in riparian areas are cottonwood and Russian olive, an invasive species. Irrigation has contributed to salinity levels in the Green River and tributaries. The mean number of frost-free days is 115 to 140, with cold winters.

The North Uinta Basin Slopes subregion includes numerous perennial streams originating from the adjacent mountains. Pinyon-juniper woodland is the most common habitat type in this subregion, with some sagebrush steppe. Upper elevations support mountain brush communities. Cottonwood, willow, ponderosa pine, and shrubs occur in canyons. Annual precipitation is 8 to 18 in., and the mean number of frost-free days is 100 to 130.

The Sand Deserts subregion is arid with only 5 to 8 in. of annual precipitation. The sandy soils have a low water-holding capacity. Vegetation is generally sparse or absent and is typically composed of desert or semidesert grasses, desert shrubs, and annual forbs. Galleta-three awn (*Aristida purpurea*) shrubsteppe is the most common habitat type, with saltbush-greasewood shrubsteppe and pinyon-juniper woodland also present. Grasses include indian ricegrass, sand dropseed, galleta, and three awn; shrubs include blackbrush in southern areas, and sandsage. Yucca (*Yucca angustissma*) is also present. This subregion includes areas of unstabilized sand dunes and exposed bedrock. The mean number of frost-free days ranges from 130 to 180.

The Wasatch and Uinta Mountains ecoregion includes the Wasatch Montane Zone and Mountain Valleys subregions. The predominant habitat type in the Wasatch Montane Zone subregion is Douglas fir forest. Forests of Engelmann spruce-subalpine fir are found mostly to the south. Aspen parkland, which includes big sagebrush, snowberry, elderberry, mountain grasses, and scattered Douglas fir, also occurs in this subregion. This subregion includes many good quality perennial streams. Willow and birch occur along streams. Annual precipitation is 16 to 50 in. or more, the east side being drier than the west side. The mean number of frost-free days ranges from less than 40 to 80, with long, cold winters.

The Mountain Valleys subregion is unforested. The predominant habitat type is Great Basin sagebrush steppe, with pinyon-juniper woodland also present. Cottonwood, Russian olive, and invasive species are found in riparian areas. Annual precipitation is 5 to 24 in. The mean number of frost-free days is 70 to 100.

A number of species are endemic to the Green River shale barrens, generally on soils of the Parachute Creek or Evacuation Creek member of the Green River Formation, as well as the Uinta Formation (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006i). These soils are generally shallow, dry, and fine textured with abundant white to light tan shale fragments on the surface. These oil-shale endemic species are adapted to the xeric and highly basic calcareous shale soils, which in some locations can be erosive, and often have a taproot and condensed growth habit. Plant communities at these locations can be varied and include open desert shrub, mixed desert shrub, or open pinyon-juniper communities (Goodrich and Neese 1986; Welsh and Thorne 1979; Atwood et al. 1991; UDWR 2006; USFWS 2006i). Occurrences of these endemics are often located within a narrow band along the southern margin of the Uinta Basin. Many oil-shale endemics, such as the shrubby reed-mustard (*Schoenocrambe suffrutescens*), have extremely limited distributions, and are found only in Utah (UDWR 2006). Others are also known from sites in Colorado or Wyoming. A number of these endemic species are expected to occur in STSAs. For example, Graham's beardtongue (*Penstemon grahamii*) and the White River beardtongue (*Penstemon scariosus albifluvis*) potentially occur in the Hill Creek, Pariette, P.R. Spring, and Raven Ridge STSAs. The White River beardtongue may also occur in the Asphalt Ridge STSA. Shrubby reed-mustard potentially occurs in the Hill Creek, Pariette, P.R. Spring, and Sunnyside STSAs. These endemic species often occur as small scattered populations. Because of their small populations and vulnerability, many oil-shale endemics are federally listed, state-listed, or BLM sensitive species (Section 3.7.4). Some oil-shale endemics (e.g., dragon milk-vetch [*Astragalus lutosus*], fragrant cryptantha [*Cryptantha grahamii*], Barneby's columbine [*Aquilegia barnebyi*], Barneby's thistle [*Cirsium barnebyi*], and Barneby's cryptantha [*Cryptantha barnebyi*]) have no official conservation status (UDWR 2006). Each of these species potentially occurs in one or more STSAs. Flowers' penstemon (*Penstemon flowersii*), endemic to the Uinta Basin (although not endemic to shale soils), is restricted to a small area of Duchesne and neighboring Uintah Counties and may occur in the Pariette STSA; it also has no formal conservation status (UDWR 2006).

A number of existing and potential ACECs intersect with the STSAs. Many of these ACECs contain riparian habitats, wetlands, remnant vegetation associations, and/or endemic plant species.

- Asphalt Ridge STSA is located near the Red Mountain–Dry Fork Complex ACEC, which supports two relic vegetation communities.
- Pariette STSA intersects with Pariette Wetlands ACEC, which includes special status and listed plant species and extensive wetlands.
- P.R. Spring STSA is located adjacent to Cottonwood/Diamond Watershed ACEC.
- Raven Ridge STSA is located near the Raven Ridge ACEC.
- San Rafael STSA intersects with San Rafael Canyon, San Rafael Reef, which includes relict vegetation communities, and I-70 Scenic Highway ACECs, and is located near the Muddy Creek ACEC, which has important riparian vegetation habitat.
- Sunnyside STSA intersects with Nine Mile Canyon ACEC and Lears Canyon ACEC, with relict plant communities and special status plant species, Nine Mile Canyon Expansion, Desolation Canyon, and Range Creek ACECs.

3.7.3 Wildlife

As discussed in Section 3.7.2, the various ecoregions encompassed by the oil shale and tar sands study area (i.e., counties within which commercial-scale development may occur) include a diversity of plant communities and species which, in turn, provide a wide range of habitats that support diverse assemblages of terrestrial wildlife. Table 3.7.3-1 lists the number of wildlife species that occur within the oil shale and tar sands study area. The wildlife species that may be associated with any particular project would depend on the specific location of the project and on the plant communities and habitats present at the site.

The Federal Land Policy and Management Act (FLPMA) of 1976 chartered the BLM with the responsibility of maintaining or enhancing wildlife habitats that occur on public lands. The BLM manages wildlife through resource allocations and objectives described in RMPs. The RMPs are designed to balance the conservation of wildlife and other natural resources with the needs of the public. The BLM's Wildlife Management Program maintains and manages wildlife habitats to help ensure self-sustaining populations and a natural abundance and diversity of wildlife on public lands. In order to provide for the long-term protection of wildlife resources, the BLM supports habitat conservation and restoration activities, many funded through partnerships with federal, state, and non-governmental organizations. The BLM wildlife habitat management program places special emphasis on, but is not limited to, the protection, maintenance, and enhancement of (1) crucial habitats for big game, upland game birds, and waterfowl; (2) crucial habitats for nongame species of special interest and concern to state or other federal agencies; (3) wetland and riparian habitats; (4) existing or potential fisheries habitats; and (5) habitat for state or federally listed threatened and/or endangered species. State agencies (i.e., Colorado Division of Wildlife [CDOW[16]], Utah Division of Wildlife Resources [UDWR], and Wyoming Game and Fish Department [WGFD]), in cooperation with the BLM, are responsible for managing wildlife species. The USFWS has principal statutory responsibility and authority for migratory birds, threatened and endangered species, international resources within the continental United States, and all fish and wildlife on lands under USFWS control. The USFWS administers the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act, and is required by the ESA to assist all federal agencies in ensuring that any action that those agencies authorize, implement, or fund will not jeopardize the continued existence of any federally endangered and/or threatened species. Threatened and endangered species are provided in Section 3.7.4.

Consumptive and nonconsumptive recreational uses are associated with wildlife within BLM-administered lands. These include hunting of big game, small game, upland game birds, and fur trapping; wildlife viewing; and antler hunting (BLM 2004a).

The following discussions present general descriptions of the wildlife species that may be affected by oil shale and tar sands projects on BLM-administered lands within the study area.

3.7.3.1 Amphibians and Reptiles

The number of amphibian (frogs, toads, and salamanders) and reptile (turtles, lizards, and snakes) species in the counties within the oil shale and tar sands study area are presented in Table 3.7.3-1. Common amphibian species include the tiger salamander (*Ambystoma tigrinum*), Great Basin spadefoot (*Spea intermontana*), northern leopard frog (*Rana pipiens*), and Woodhouse's toad (*Bufo woodhousii*). Reptile species common or widely distributed within the study areas include common gartersnake (*Thamnophis sirtalis*), racer (*Coluber constrictor*), gopher snake (*Pituophis catenifer*), midget faded rattlesnake (*Crotalus oreganus*), striped whipsnake (*Masticophis taeniatus*), western terrestrial garter snake (*Thamnophis elegans*), common side-blotched lizard (*Uta stansburiana*), eastern collared lizard (*Crotaphytus collaris*), eastern fence lizard (*Sceloporus undulatus*), and short-horned lizard (*Phrynosoma douglassii*). In Colorado, larval tiger salamanders, bullfrogs (*Rana catesbeiana*), snapping turtles (*Chelydra serpentina*), and prairie rattlesnakes (*Crotalus viridis*) are classified as game species, while all others are classified as nongame wildlife (CDOW 2001). Threatened, endangered, and protected amphibian and reptile species are addressed in Section 3.7.4.

3.7.3.2 Birds

From 168 to 360 species of birds have been reported from the counties within the oil shale and tar sands study area (Table 3.7.3-1). The number of species listed for each county, particularly Utah, do not imply that all species could be found in a potential oil shale or tar sands

[16] Note that on July 1, 2011, Colorado State Parks and the Colorado Division of Wildlife were merged to form Colorado Parks and Wildlife.

TABLE 3.7.3-1 Number of Wildlife Species Occurring within the Oil Shale and Tar Sands Study Area

State	County	Amphibians	Reptiles	Birds	Mammals
Colorado	Garfield	8	20	274	74
	Rio Blanco	7	19	279	78
	State Total	18	51	491	130
Utah	Carbon	7	22	176	82
	Duchesne	8	20	235	85
	Emery	8	21	168	87
	Garfield	10	27	235	80
	Grand	9	20	236	79
	San Juan	10	27	360	85
	Uintah	6	18	280	88
	Utah	9	27	325	85
	Wasatch	9	24	243	71
	Wayne	10	23	239	79
	State Total	17	57	448	134
Wyoming	Lincoln	6	5	252	78
	Sublette	5	4	233	68
	Sweetwater	4	8	309	86
	Uinta	6	5	252	78
	State Total	12	26	434	121

Sources: CDOW (2011); Colorado Field Ornithologists (2008, 2010, 2011); Orabona et al. (2009); UDWR (2011a); Utah Birds (2007a–e, 2010, 2011a–e); WGFD (2009).

development area. For example, some species may be restricted to small areas within the corridor of the Green River.

Many of the bird species identified from the study area are seasonal residents and exhibit seasonal migrations. These include many of the waterfowl, shorebird, raptor, and neotropical songbird species. The area where commercial-scale oil shale and tar sands development may occur on BLM-administered lands falls primarily within the Central Flyway (Figure 3.7.3-1). Birds migrating north from wintering areas to breeding areas use this flyway in the spring, and birds migrating southward to wintering areas use it in the fall. The flyway encompasses a broad geographic area and includes a number of specific routes that would be an important parameter for identifying site-specific concerns related to migratory birds.

The Central Flyway includes the Great Plains–Rocky Mountain routes (Lincoln et al. 1998). These routes extend from the northwestern Arctic coast southward between the Mississippi River and the Rocky Mountains and encompass all or most of Colorado and Wyoming and portions of Utah. The flyway is relatively simple; the majority of the birds make direct north and south migrations between northern breeding grounds and southern wintering areas (Birdnature.com 2001).

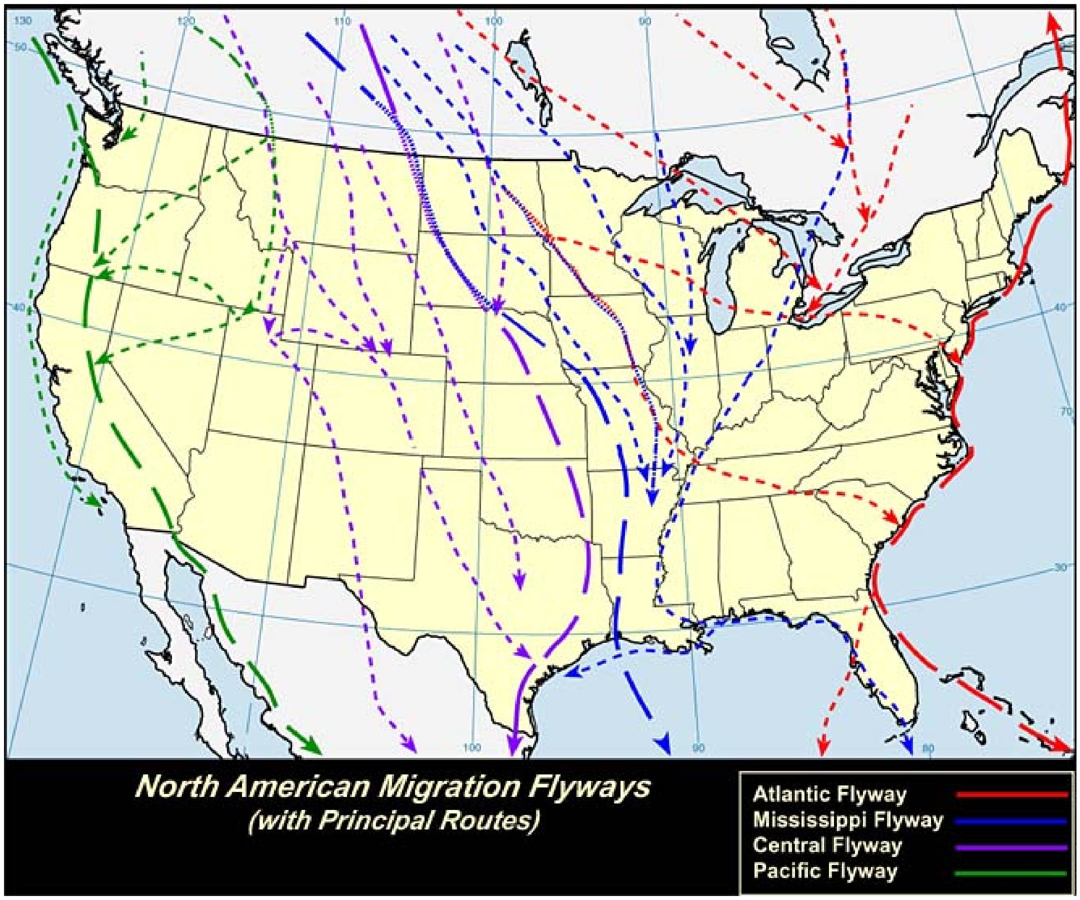

FIGURE 3.7.3-1 North American Migration Flyways (Coarse dashed lines are major flyways, medium dashed lines are principal migratory routes, fine dashed lines are merging routes; used with permission of birdnature.com, June 7, 2006.)

The following discussion describes groups or species of birds that (1) have key habitats within or near the areas that could be developed for oil shale and tar sands, (2) are important to humans (e.g., waterfowl and upland game species), (3) are representative of other species that share important habitats, and/or (4) receive regulatory protection (e.g., those species protected by the Migratory Bird Treaty Act or the Bald and Golden Eagle Protection Act). Threatened, endangered, and protected bird species are addressed in Section 3.7.4.

3.7.3.2.1 Waterfowl, Wading Birds, and Shorebirds. Waterfowl (ducks, geese, and swans), wading birds (herons and cranes), and shorebirds (plovers, sandpipers, and similar birds) include bird species that belong to the orders Anseriformes, Charadriformes, Gaviformes, Podicipediformes, Pelicaniformes, and Gruiformes. Species from these orders are among the more abundant groups of birds from the study area. Many of these species exhibit extensive migrations from breeding areas in Alaska and Canada to wintering grounds in Mexico and southward (Lincoln et al. 1998). Most are ground-level nesters, and many forage in flocks (sometimes relatively large) on the ground or water. Within the study area, migration routes for these birds are often associated with riparian corridors and wetland or lake stopover areas (BLM 2008b).

Common to abundant waterfowl, wading bird, and shorebird species that occur within the oil shale and tar sands study area include Canada goose (*Branta canadensis*), green-winged teal (*Anas crecca*), mallard (*Anas platyrhynchos*), northern shoveler (*Anas clypeata*), gadwall (*Anas strepera*), ring-necked duck (*Aythya collaris*), great blue heron (*Ardea herodias*), killdeer (*Charadrius vociferous*), spotted sandpiper (*Actitis macularius*), and Wilson's phalarope (*Phalaropus tricolor*) (CDOW 2011; Orabona et al. 2009; UDWR 2011a). Major waterfowl species harvested in the study area include mallard and Canada goose. Other species commonly harvested include gadwall, American widgeon (*Anas americana*), teal (*Anas* spp.), northern pintail (*Anas acuta*), northern shoveler, and snow goose (*Chen caerulescens*) (Raftovich et al. 2011). A hunting season also occurs for sandhill crane (*Grus canadensis*).

3.7.3.2.2 Passerines and Other Landbirds. Passerines and other landbirds include species that belong to the bird orders Passeriformes, Cuculiformes, Caprimulgiformes, Apodiformes, Coraciiformes, and Piciformes. Many of the birds in this group (as well as the other bird groups, with the exception of upland game birds) are neotropical migrants that breed in North America during spring and early summer and winter in Mexico, the Caribbean, and Central and South America. The several hundred species of neotropical migrants include songbirds, shorebirds, waterfowl, and some raptors. The BLM is a participant in Partners in Flight, a cooperative effort involving federal, state, and local government agencies, philanthropic foundations, professional organizations, conservation groups, industry, the academic community, and private individuals that focuses on the conservation of landbirds and other bird species that require terrestrial habitats. Specific biological objectives and recommendations for landbirds are presented in the bird conservation plans for each state (Beidleman 2000 [Colorado]; Nicholoff 2003 [Wyoming]; Parrish et al. 2002 [Utah]).

The passerines and other landbirds exhibit a wide range of seasonal movements; some species are year-round residents in some areas and migratory in other areas, while other species migrate hundreds of miles or more (Lincoln et al. 1998). Many of the species utilize riparian areas and corridors for nesting and migration purposes (BLM 2008b). Nesting occurs in vegetation from near ground level to the upper canopy of trees. Some species, such as thrushes and chickadees, are relatively solitary throughout the year; other species, such as swallows and blackbirds, may occur in small to large flocks at various times of the year. Foraging may occur in flight (e.g., swallows and swifts), in vegetation, or on the ground (e.g., warblers, finches, and thrushes).

Species common to the area include dusky flycatcher (*Empidonax oberholseri*), Say's phoebe (*Sayornis saya*), cliff swallow (*Petrochelidon pyrrhonota*), canyon wren (*Catherpes mexicanus*), Bewick's wren (*Thryomanes bewickii*), Mountain bluebird (*Sialia currucoides*), sage thrasher (*Oreoscoptes montanus*), black-throated gray warbler (*Dendroica nigrescens*), yellow warbler (*Dendroica petechia*), western tanager (*Piranga ludoviciana*), black-headed grosbeak (*Pheucticus melanocephalus*), Brewer's sparrow (*Spizella breweri*), chipping sparrow

(*Spizella passerine*), Brewer's blackbird (*Euphagus cyanocephalus*), and brown-headed cowbird (*Molothrus ater*).

3.7.3.2.3 Upland Game Birds. The upland game birds include species that belong to the orders Galliformes and Columbiformes. Upland game birds that are native to the study area include blue grouse (*Dendragapus obscurus*), ruffed grouse (*Bonasa umbellus*), greater sage-grouse (*Centrocercus urophasianus*), and mourning dove (*Zenaida macroura*). Introduced species include ring-necked pheasant (*Phasianus colchicus*), chukar (*Alectoris chukar*), gray partridge (*Perdix perdix*), and wild turkey (*Meleagris gallopavo*). All of the upland game bird species within the study area are year-round residents. Most concerns over upland game birds in the West have focused on the greater sage-grouse because of its dependence on sagebrush. The greater sage-grouse, a candidate for listing under the ESA, is discussed in Section 3.7.4.

3.7.3.2.4 Raptors. The birds of prey include the raptors (hawks, falcons, eagles, kites, and osprey), owls, and vultures (hereafter referred to collectively as raptors). Raptors include species that belong to the orders Falconiformes, Cathartiformes, and Strigiformes. Many of these species represent the top avian predators. Common species in the study area include the turkey vulture (*Cathartes aura*), sharp-shinned hawk (*Accipiter striatus*), red-tailed hawk (*Buteo jamaicensis)*, northern harrier (*Circus cyaneus*), Swainson's hawk (*Buteo swainsoni*), American kestrel (*Falco sparvenus*), golden eagle (*Aquila chrysaetos*), great horned owl (*Bubo virginianus*), and short-eared owl (*Asio flammeus*). The raptors vary considerably among species with regard to their seasonal migrations; some species are nonmigratory, others may be migratory in the northern portion of their ranges and nonmigratory in the southern portions, and others are migratory throughout their ranges. Species that nest in the study area include the golden eagle, prairie falcon (*Falco mexicanus*), peregrine falcon (*Falco peregrinus*), red-tailed hawk, ferruginous hawk (*Buteo regalis*), American kestrel, Coopers hawk (*Accipiter cooperii*), sharp-shinned hawk, northern goshawk (*Accipiter gentilis*), great horned owl, northern saw-whet owl (*Aegolius acadicus*), and burrowing owl (*Athene cunicularia*) (CDOW 2011; Orabona et al. 2009; UDWR 2011a).

Depending on the species, the raptors consume a variety of prey, including small mammals, reptiles, other birds, fishes, invertebrates, and carrion. They typically perch on trees or man-made structures that provide a view of the surrounding topography; they may soar for extended periods of time at relatively high altitudes. Raptors typically forage from either a perch or on the wing (depending on the species). While generally nocturnal, some owl species may be active during the day. The other raptor species typically forage during the day.

3.7.3.3 Mammals

The number of mammal species within the counties in the study area range from 68 to 88 species (Table 3.7.3-1). Feral cats (*Felis catus*) and dogs (*Canis familiaris*) also occur in the study area. The following discussion emphasizes big game and small mammal species that (1) have key habitats within or near the study area that could be developed for oil shale and tar sands, (2) are important to humans (e.g., big game species), and/or (3) are representative of other species that share important habitats. Threatened, endangered, and other protected mammal species are addressed in Section 3.7.4.

3.7.3.3.1 Big Game. Big game species within the study area include elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocarpra americana*), bighorn sheep (*Ovis canadensis*), moose (*Alces americanus*), American black bear (*Ursus americanus*), and cougar (*Felis concolor*). The elk and mule deer are generally the most abundant, widely distributed, intensely managed, and sought-after big game in the study area (BLM 2006a). Some of the big game species make migrations when seasonal changes reduce food availability, when movement becomes difficult (e.g., due to snowpack), or where local conditions are not suitable for calving or fawning. Established migration corridors for these species provide an important transition range between seasonal ranges and provide food for the animals during migration (Feeney et al. 2004). Water availability is a major factor affecting the distribution of big game species (BLM 2004b).

Elk. Elk are mostly migratory between their summer and winter ranges (BLM 2008c), although some herds do not migrate (i.e., occur within the same general area year-round) (UDWR 2010). Summer range occurs at higher elevations. Aspen and conifer woodlands provide security and thermal cover, while upland meadows, sagebrush-mixed grass, and mountain shrub habitat types are used for forage. Winter range occurs at mid to lower elevations where elk forage in sagebrush-mixed grass, big sagebrush-rabbitbrush, and mountain shrub habitat types (BLM 2006a). Elk are highly mobile within both summer and winter ranges in order to find the best forage conditions. In winter, they will congregate in large herds of 50 to more than 200 individuals (BLM 2008c). Crucial winter range is considered to be the part of the local elk range, where about 90% of the local population is located during an average of 5 winters out of 10 from the first heavy snowfall to spring greenup (BLM 2008b). Elk calving generally occurs in aspen-sagebrush parkland vegetation and habitat zones during late spring and early summer (BLM 2008c). Calving areas are mostly located where cover, forage, and water are in close proximity (BLM 2008b). Elk require water on all seasonal ranges and generally occur within 0.5 mi of a water source, although some herds will travel longer distances for water (UDWR 2010). Elk are susceptible to chronic wasting disease (CDC 2011).

Mule Deer. Mule deer occur within most ecosystems within the region but attain their highest densities in shrublands characterized by rough, broken terrain with abundant browse and cover (CDOW 2011). Some populations of mule deer are resident (e.g., occur in the same location throughout the year), but those in mountainous areas are generally migratory between their summer and winter ranges. Home range size may vary from about 75 to more than 590 acres (NatureServe 2011). Summer range occurs at higher elevations that contain aspen and conifer and mountain browse vegetative types. Fawning occurs during the spring while the mule deer are migrating to their summer range. This normally occurs in aspen-mountain browse intermixed vegetation types (BLM 2008c). Mule deer have a high fidelity to specific winter ranges where they will congregate within a small area at a high density. Winter range occurs at lower elevations within sagebrush and pinyon-juniper vegetation types. Winter forage is primarily sagebrush with true mountain mahogany, fourwing saltbush, and antelope bitterbrush also being important. Pinyon-juniper provides emergency forage during severe winters (BLM 2008c). Overall, mule deer habitat is characterized by areas of thick brush or trees (used for cover) interspersed with small openings (for forage and feeding areas); they do best in habitats that are in the early stage of succession (UDWR 2008).

Prolonged drought and other factors can limit mule deer populations. Several years of drought can limit forage production, which can substantially reduce animal condition and fawn production and survival. Severe drought conditions were responsible for declines in the population size of mule deer in the 1980s and early 1990s (BLM 2008c). In arid regions, they seldom occur more than 1.0 to 1.5 mi from water (BLM 2004b). Mule deer are also susceptible to chronic wasting disease. When it is present, up to 3% of a herd population can be affected by this disease. Some deer herds in Colorado and Wyoming have experienced significant outbreaks of chronic wasting disease (BLM 2008c).

Pronghorn. Pronghorn inhabit open vegetated areas such as desert, grassland, and sagebrush habitats (BLM 2008b). Herd size can commonly exceed 100 individuals, especially during winter (BLM 2008c). They consume a variety of forbs, shrubs, and grasses, with shrubs being most important in winter (BLM 2008c). Some pronghorn are year-long residents and do not have seasonal ranges. Fawning occurs throughout the species range. However, some seasonal movement within their range occurs in response to factors such as extreme winter conditions and water or forage availability (BLM 2006a, 2008c). Other pronghorn are migratory. Most herds range within an area of 5 mi or more in diameter, although the separation between summer and winter ranges has been reported to be as much as 99 mi or more (NatureServe 2011). For example, in western Wyoming, pronghorn migrate 116 to 258 km (72 to 160 mi) between ranges (Sawyer et al. 2005). Severe winters with deep, crusted snow and below-zero temperatures can cause high pronghorn mortalities (BLM 2004b). Pronghorn populations have also been adversely impacted in some areas by historic range degradation and habitat loss and by periodic drought conditions (BLM 2004b, 2008b,c).

Bighorn Sheep. Rocky Mountain bighorn sheep (*Ovis c. canadensis*) and desert bighorn sheep (*O. Canadensis nelsoni*) are considered to be year-long residents within their ranges; they do not make seasonal migrations like elk and mule deer (BLM 2008c). However, they do make vertical migrations in response to increasing abundance of vegetative growth at higher elevations in the spring and summer, and when snow starts to accumulate in high-elevation summer ranges (NatureServe 2011). Ewes also move to reliable watercourses or sources during the lambing season; lambing occurs on steep talus slopes within 1 to 2 mi of water (BLM 2008c). Bighorn sheep prefer open vegetation types such as low shrub, grassland, and other treeless areas with steep talus and rubble slopes (BLM 2006a). Their diet consists of shrubs, forbs, and grasses (BLM 2008c). In the early 1900s, bighorn sheep experienced significant declines because of disease, habitat degradation, and hunting (BLM 2008b). Bighorn sheep are very vulnerable to viral and bacterial diseases carried by livestock, particularly domestic sheep. Therefore, the BLM has adopted specific guidelines regarding domestic sheep grazing in or near bighorn sheep habitat (BLM 2008c). In appropriate habitats, reintroduction efforts, coupled with water and vegetation improvements, have been conducted to restore bighorn sheep to their native habitat (BLM 2008c).

Moose. Although moose range widely among habitat types, they are mainly associated with boreal forests and riparian areas. Their preferred habitat is generally associated with early stages of seral development and shrub growth (BLM 2008b). Moose also will make use of dense stands of conifers for shelter in winter and for thermoregulation in summer (UDWR 2009). They are primarily browsers upon trees and shrubs such as willow, fir, and quaking aspen; grasses, forbs, and aquatic vegetation, however, make up a large portion of the summer diet (BLM 2008b). Moose habitat is thought to be improved by annual flooding and habitat management techniques such as prescribed burning (BLM 2008b). Moose generally occur singly or in small groups. Some moose make short elevational or horizontal migrations between summer and winter habitats (NatureServe 2011). In addition to predation, snow accumulation may have a controlling effect on moose populations. Habitat degradation resulting from a large number of moose can lead to population crashes (NatureServe 2011).

Cougar. Cougars (also known as mountain lions or puma) inhabit most ecosystems in the study area but are most common in the rough, broken terrain of foothills and canyons, often in association with montane forests, shrublands, and pinyon-juniper woodlands (BLM 2008b). Their annual home range can be more than 560 mi^2, although densities are usually not more than 10 adults/100 mi^2 (NatureServe 2011). The mountain lion is generally found where its prey species (especially mule deer) are located (BLM 2008c). They also prey upon most other mammals (which sometimes include domestic livestock) and some insects, birds, fishes, and berries (CDOW 2011). They are active year-round and are hunted on a limited and closely monitored basis (BLM 2008c).

American Black Bear. American black bears are found mostly within forested or brushy mountain environments and woody riparian corridors (BLM 2008b). They are omnivorous and feed on fruits, insects, small vertebrates, and carrion (CDOW 2011; UDWR 2011b). Breeding occurs in June or July; the young are born in January or February (UDWR 2011b). American black bears have a period of winter dormancy from November to April (BLM 2008b). The home range of the American black bear depends on the area in which it lives and the bear's gender; its range has been reported to be from about 1,250 to nearly 32,000 acres (NatureServe 2011).

3.7.3.3.2 Small Mammals. Small mammals include small game, furbearers, and nongame species. Small game species that commonly occur within the oil shale and tar sands study area include black-tailed jackrabbit (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), mountain cottontail (*Sylvilagus nuttallii*), snowshoe hare (*Lepus americanus*), white-tailed jackrabbit (*Lepus townsendii*), and yellow-bellied marmot (*Marmota flaviventris*). Common furbearers include American badger (*Taxidea taxus*), American beaver (*Castor canadensis*), American marten (*Martes americana*), bobcat (*Lynx rufus*), common muskrat

(*Ondatra zibethicus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitus*), and weasels. Nongame species include bats, shrews, mice, voles, chipmunks, and other rodent species.

3.7.4 Threatened, Endangered, and Sensitive Species

This section addresses species that are federally or state-listed and are included in one of the following categories:

- Species listed as threatened or endangered, proposed for listing as threatened or endangered, or considered a candidate for listing as threatened or endangered by the USFWS. These species are protected under the ESA.

- Species listed as sensitive by the BLM in Colorado, Utah, or Wyoming.

- Species listed as threatened, endangered, or of special concern by the states of Colorado, Utah, or Wyoming.

The following definitions apply to species listed under the ESA:

- *Endangered*. Any species that is in danger of extinction throughout all or a significant portion of its range.

- *Threatened*. Any species that is likely to become endangered within the foreseeable future throughout all or a significant part of its range.

- *Proposed*. Any species that has been formally proposed for listing as threatened or endangered by the USFWS by notice in the *Federal Register.*

- *Candidate*. Any species for which the USFWS has sufficient information on its biological status and threats to propose it for listing as endangered or threatened under the ESA, but for which development of a listing regulation is precluded by other, higher-priority listing activities. Candidate species receive no statutory protection under the ESA, but by definition these species may warrant future protection under the ESA.

- *Critical habitat*. Specific areas within the geographical area occupied by the species at the time it is listed, on which are found physical or biological features essential to the conservation of the species and which may require special management considerations or protection. Except when designated, critical habitat does not include the entire geographical area that can be occupied by the threatened or endangered species.

On the lands that it administers, the BLM is required under FLPMA to manage plant and wildlife species. For species that are listed or proposed for listing under the ESA, the BLM is to ensure that its actions do not jeopardize those species or adversely modify or destroy proposed or designated critical habitat. ESA requirements pertinent to BLM activities are addressed in *BLM Manual 6840—Special Status Species Management* (BLM 2008h), which establishes Special Status Species policy for plant and animal species and the habitats on which they depend. The Special Status Species policy refers not only to species listed under the ESA, but also to those designated by the BLM State Director as “sensitive.” *BLM Manual 6840* defines a sensitive species as a species that could easily become endangered or extinct in the state and for which the BLM has the capability to significantly affect the conservation status of the species. The list of BLM-designated sensitive species varies from state to state, and the same species can be considered sensitive in one state but not in another.

The states of Colorado, Utah, and Wyoming have identified species that are of special concern. In addition, the State of Colorado maintains a list of species that are considered threatened or endangered in that state. The BLM’s current policy is to manage candidates for federal listing, BLM-designated sensitive species, state-listed species, and state species of special concern to prevent future federal listing as threatened or endangered.

A total of 246 plant and animal species are either federally (USFWS and BLM) or state-listed (Colorado, Utah, and Wyoming) and occur or could occur in counties within oil shale basins or STSAs. These species and their habitats are presented in Table E-1 of Appendix E. Table 3.7.4-1 gives the number of these species in different taxonomic groups and according to listing category. In the study area counties, 39 species are listed, proposed, or candidates for listing by the USFWS under the ESA; 110 species are listed as sensitive by the BLM; 24 are listed by the State of Colorado; 28 are listed by the State of Utah; and 143 are listed by the State of Wyoming.

Table 3.7.4-2 gives the number of species, by listing category, that could occur within oil shale basins or STSAs where development could occur. The largest number of species listed or candidates for listing by the USFWS under the ESA potentially occurs within STSAs, but this reflects the more dispersed nature of these areas and consequently, the larger overall area and potential for a wider range of habitats.

3.7.4.1 Species Listed under the Endangered Species Act

There are 39 species that are listed or candidates for listing by the USFWS under the ESA and that occur in the counties in which oil shale basins and STSAs under consideration in this PEIS are located. The likelihood of occurrence in study areas cannot be fully determined at this time because actual project locations and footprints will not be determined until some later date. A complete evaluation of listed species in the study areas will be made at that time, before leasing or development is approved. Listed species that could occur in the study areas (based on National Heritage Program information and state and federal records) are discussed in this section and presented in alphabetical order. Basic information is provided on life history, habitat needs, and threats to populations. Included is the likelihood of their presence within oil shale basins and STSAs (Table 3.7.4-3).

TABLE 3.7.4-1 Federally and State-Listed Species According to Taxonomic Group That Occur in Counties with the Potential for Oil Shale or Tar Sands Development

	Taxonomic Group							
Status	Plants	Invertebrates	Fish	Amphibians	Reptiles	Birds	Mammals	Total
USFWS								
Endangered	7	0	5	0	0	2	0	14
Threatened	14	0	0	0	0	1	2	16
Proposed	1	0	0	0	0	0	0	1
Candidate	1	0	0	0	0	3	1	5
Experimental, nonessential	0	0	0	0	0	1	1	2
Total	22	0	5	0	0	7	4	39
BLM								
Sensitive	49	5	6	6	6	22	16	110
State of Colorado								
Endangered	0	0	2	1	0	1	4	8
Threatened	0	0	2	0	0	2	0	4
Special concern	0	0	2	1	2	8	1	14
Total	0	0	6	2	2	11	5	26
State of Utah								
Special concern	0	4	1	2	4	7	12	30
State of Wyoming								
Special concern	78	0	6	4	3	30	22	143
Total species[a]	129	5	11	7	9	52	33	246

[a] Totals represent the total number of listed species within oil shale basins and STSAs and do not represent the sum of row values. Species can be listed by both state and federal governments.

3.7.4.1.1 Autumn Buttercup. The autumn buttercup is a perennial herbaceous plant that is endemic to the Sevier River Valley in western Garfield County, Utah (UDWR 2006). Currently, only two small autumn buttercup populations are known. Its habitat is low, herbaceous wet meadow communities on drier peat hummocks, or in open areas of these communities; it is found at elevations of about 1,940 to 1,980 m (6,365 to 6,496 ft). Sagebrush-dominated plant communities typically are found surrounding wetland communities. The presence of freshwater seeps and lack of livestock grazing seem to be important habitat elements needed for species survival (NatureServe 2011).

The autumn buttercup was listed as federally endangered on July 21, 1989 (54 FR 20550), and a recovery plan was prepared on September 16, 1991 (USFWS 1991a). The recovery plan had a goal of preventing extinction and establishing populations in unoccupied

TABLE 3.7.4-2 Federally and State-Listed Species That Occur within Counties with the Potential for Oil Shale or Tar Sands Development

Status	Oil Shale Basins and STSAs					
	Green River	Washakie	Piceance	Uinta	STSAs	Total[a]
USFWS						
Endangered	1	0	2	7	11	14
Threatened	1	0	6	7	10	17
Proposed	0	0	0	1	1	1
Candidate	1	1	3	3	5	5
Experimental, nonessential	1	1	2	1	1	2
Total	3	2	13	18	28	39
BLM						
Sensitive	55	38	46	42	58	110
State of Colorado						
Endangered	0	0	7	0	0	8
Threatened	0	0	3	0	0	4
Special concern	0	0	14	0	0	14
Total	0	0	24	0	0	26
State of Utah						
Special concern	0	0	0	19	25	30
State of Wyoming						
Special concern	147	107	0	0	0	143
Total species[b]	139	97	59	59	83	246

[a] Totals equal the number of species within listing categories and do not represent the sum of column values. Listed species can occur in more than one basin or STSA.

[b] Totals represent the total number of listed species within oil shale basins and STSAs and do not represent the sum of row values. Species can be listed by both state and federal governments and can occur in multiple oil shale basins and STSAs.

suitable habitat. Criteria for successful recovery included increasing the current population to about 1,000 plants on 10 acres, preserving the species under greenhouse conditions, and establishing additional populations of at least 20,000 individuals.

The Center for Plant Conservation (CPC 2006a) reports that a survey of the only known autumn buttercup population in 1982 indicated a total of 400 plants. By 1988, the population had dropped to only 10 to 20 individual plants. A 44-acre parcel supporting this population was purchased by the Nature Conservancy in 1989 and was named the Sevier Valley Preserve. An additional population of about 200 plants was found shortly after the land was purchased (CPC 2006a). The Nature Conservancy has fenced the 44-acre parcel to exclude livestock grazing in an attempt to protect the autumn buttercup and increase its chances of reproduction.

TABLE 3.7.4-3 Occurrence of Species Listed or Candidates for Listing under the Endangered Species Act That Occur in Counties with the Potential for Oil Shale or Tar Sands Development

			Known or Potential Occurrence in Oil Shale Basins and STSAs[b]				
Species	Scientific Name	Listing Status[a]	Green River	Washakie	Piceance	Uinta	STSAs
Autumn buttercup	*Ranunculus aestivalis*	E	–	–	–	–	–
Barneby reed-mustard	*Schoenocrambe barnebyi*	E	–	–	–	–	×
Barneby ridge-cress	*Lepidium barnebyanum*	E	–	–	–	×	–
Black-footed ferret	*Mustela nigripes*	XN	×	×	×	×	×
Bonytail	*Gila elegans*	E	–	–	–	×	×
California condor	*Gymnogyps californianus*	E	–	–	–	–	×
Canada lynx	*Lynx canadensis*	T	×	–	×	×	×
Clay phacelia	*Phacelia argillacea*	E	–	–	–	×	–
Clay reed-mustard	*Schoenocrambe argillacea*	T	–	–	–	×	×
Colorado hookless cactus	*Sclerocactus glaucus*	T	–	–	×	–	–
Colorado pikeminnow	*Ptychocheilus lucius*	E	–	–	×	×	×
Debeque phacelia	*Phacelia scopulina* var. *submutica*	T	–	–	×	–	–
Dudley Bluffs bladderpod	*Lesquerella congesta*	T	–	–	×	–	–
Dudley Bluffs twinpod	*Physaria obcordata*	T	–	–	×	–	–
Graham's beardtongue	*Penstemon grahamii*	PT	–	–	–	×	×
Greater sage-grouse	*Centrocercus urophasianus*	C	×	×	×	×	×
Gunnison prairie dog	*Cynomys gunnisoni*	C	–	–	–	–	–
Gunnison sage-grouse	*Centrocercus minimus*	C	–	–	–	–	×
Humpback chub	*Gila cypha*	E	–	–	–	×	×
Jones cycladenia	*Cycladenia humilis* var. *jonesii*	T	–	–	–	–	×
Kendall Warm Spring dace	*Rhinichthys osculus thermalis*	E	×	–	–	–	–
Last chance townsendia	*Townsendia aprica*	T	–	–	–	–	×
Maguire daisy	*Erigeron maguirei*	T	–	–	–	–	×
Mexican spotted owl	*Strix occidentalis lucida*	T	–	–	–	×	×
Navajo sedge	*Carex specuicola*	T	–	–	–	–	–
Parachute beardtongue	*Penstemon debilis*	T	–	–	×	–	–
Pariette cactus	*Sclerocactus brevispinus*	T	–	–	–	×	×
Razorback sucker	*Xyrauchen texanus*	E	–	–	×	×	×
San Rafael cactus	*Pediocactus despainii*	E	–	–	–	–	×
Shrubby reed-mustard	*Schoenocrambe suffrutescens*	E	–	–	–	×	×

TABLE 3.7.4-3 (Cont.)

Species	Scientific Name	Listing Status[a]	Known or Potential Occurrence in Oil Shale Basins and STSAs[b]				
			Green River	Washakie	Piceance	Uinta	STSAs
Southwestern willow flycatcher	*Empidonax traillii extimus*	E	–	–	–	×	×
Uinta Basin hookless cactus	*Sclerocactus wetlandicus*	T	–	–	–	×	×
Utah prairie dog	*Cynomys parvidens*	T	–	–	–	–	–
Ute ladies'-tresses	*Spiranthes diluvialis*	T	–	–	–	×	×
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	C	–	–	–	×	×
White River beardtongue	*Penstemon scariosus* var. *albifluvis*	C	–	–	×	×	×
Whooping crane	*Grus americana*	XN	–	–	×	–	–
Winkler cactus	*Pediocactus winkleri*	T	–	–	–	–	×
Wright fishhook cactus	*Sclerocactus wrightiae*	E	–	–	–	–	×

[a] C = candidate; E = endangered; T = threatened; XN = experimental, nonessential population.

[b] A dash = not expected to occur in basin or STSA; × = known or potential occurrence in basin or STSA.

By 1990, the total population was estimated to be 200 individuals with 42 plants producing flowers (USFWS 1991a). The following year, researchers counted 488 plants, a substantial increase over previous years (NatureServe 2011). Many of these plants were discovered in the vicinity of the population of 200 counted in 1990. No data were found on population results for subsequent years.

The autumn buttercup grows to a height of 1 to 2 ft and usually flowers in July and August with 6 to 10 yellow flowers per plant (USFWS 1991a). Seed production occurs in late July and is completed by early September.

Potential threats to the autumn buttercup include livestock grazing on areas suitable for introduction of new populations, herbivory by voles and other small mammals, limited habitat available, and interspecies competition (NatureServe 2011). The UDWR (2006) also suggests that habitat has been altered from presettlement times by water being diverted for irrigation and introduction of domestic livestock.

Within potential development areas, the autumn buttercup occurs only in a small area of the Sevier River Valley in western Garfield County, Utah. This area is located in the southeastern portion of Garfield County. There are no known autumn buttercup populations in this area of the county or in the Tar Sand Triangle STSA in the extreme northeastern portion of the county. No populations of this species are known to occur in potential oil shale development areas.

3.7.4.1.2 Barneby Reed-Mustard. The Barneby reed-mustard is a perennial herb that is endemic to the Colorado Plateau in Emery and Wayne Counties in Utah (UDWR 2006). It occurs on steep, north-facing slopes on red, fine-textured soils that are rich in selenium and gypsum, on the Moenkopi and Chinle Formations at elevations between 1,460 and 1,985 m (4,790 and 6,512 ft). The Barneby reed-mustard grows in mixed desert shrub and pinyon-juniper communities. Common plants growing in these communities are sagebrush (*Artemisia* sp.), rabbitbrush (*Chrysothamnus nauseosus*), and Mormon tea (*Ephedra* spp.) (USFWS 1994a).

The Barneby reed-mustard was federally listed as endangered on January 14, 1992 (57 FR 1398). The USFWS prepared a recovery plan that laid out goals for recovery and management of this species and two closely related mustard species (USFWS 1994a).

Population estimates have varied from about 1,000 individual plants in the two remaining populations in 1992 to about 2,000 individuals in 2000 (CPC 2006b). One of the known populations is on BLM-administered land near Muddy Creek in the southern portion of the San Rafael Swell. The other population is in Capitol Reef National Park in the Fremont River drainage west of Fruita (USFWS 1994a).

The Barneby reed-mustard grows to heights of 10 to 25 cm (4 to 10 in.) from a branched woody base. About 5 to 20 white- or lilac-colored flowers grow on racemes at the end of the plant’s leafy stems. Flowers develop in late April through June (UDWR 2006), with seed production occurring during this period and continuing into July.

Potential threats to the Barneby reed-mustard include uranium mining activities near the population in the San Rafael Swell and foot traffic by park visitors in Capitol Reef National Park (USFWS 1994a). The range of the Barneby reed-mustard occurs near the San Rafael STSA.

3.7.4.1.3 Barneby Ridge-Cress. The Barneby ridge-cress is a perennial plant that occurs in Duchesne County, Utah. The USFWS determined that the entire known population occurs on the Uintah and Ouray Reservation of the Ute Indian Tribe (USFWS 1993a). It was first listed as endangered on September 28, 1990, and is endangered in its entire range (USFWS 2006c).

The Barneby ridge-cress occurs as a series of disjunct populations on marly shale barrens of the Uinta Formation on the three ridges at elevations between 1,890 and 1,980 m (6,201 and 6,496 ft) on both sides of Indian Creek south of the town of Duchesne (USFWS 1993a). It grows in isolated stands in desert shrub and pinyon-juniper woodland communities dominated by pinyon pine *(Pinus edulis)* and Utah juniper *(Juniperus osteosperma)*, and in association with other species that can tolerate the white shale barrens habitats situated as "islands" within unsuitable soil types from other geologic substrates. An estimated 5,000 individuals are known to grow in an area of about 200 ha (494 acres) (NatureServe 2011). Flowering occurs in April and May, seed formation in late May and June, and seed shed in June and July.

Potential threats to the Barneby ridge-cress include a variety of ground-disturbing activities such as oil and gas exploration, drilling and production, and OHV use. The USFWS determined that the entire population is underlain by petroleum deposits that were being developed as of 1993 (USFWS 1993a), although listing the species as endangered has protected it by deterring development of petroleum resources in occupied habitats. Within potential development areas, the range of the Barneby ridge-cress occurs about 25 km (16 mi) from the Pariette STSA and the Uinta Basin.

3.7.4.1.4 Black-Footed Ferret. The black-footed ferret is a small, nocturnal member of the weasel family. Its historic range and habitat requirements are closely tied to prairie dogs (*Cynomys* spp.); it lives almost exclusively in prairie-dog colonies in open grassland and uses prairie-dog burrows as dens and for shelter (USFWS 1998a). The ferrets also hunt prairie dogs, which are their principal prey.

The primary cause of the black-footed ferret population decline was the reduction in prairie dogs during the nineteenth century (USFWS 1998a). Widespread poisoning of prairie dogs to improve livestock range, loss of habitat by conversion to agriculture, and disease greatly reduced prairie-dog populations (Lockhart et al. 2006). Other threats to black-footed ferrets have included predator-control programs and diseases such as canine distemper and plague.

When the black-footed ferret was listed as an endangered species, few wild populations were known to exist. When the last known wild population disappeared in 1974, the species was thought to be extinct (USFWS 1998a). However, a small population was discovered in Wyoming in 1981. Subsequent declines in this population prompted capture of the remaining ferrets in 1986 and 1987. Currently, the only known wild populations are the result of reintroductions in

Arizona, Colorado, Montana, South Dakota, Utah, and Wyoming. Populations in Uintah and Duchesne Counties, Utah; Moffat and Rio Blanco Counties, Colorado; and a portion of Sweetwater County, Wyoming, are designated as nonessential, experimental populations (USFWS 1998a). Designation as nonessential, experimental populations assures that this is treated similarly to a species proposed for listing and may be subject to conferencing requirements under Section 7(a)(2) of the ESA to ensure that the federal actions will not jeopardize the species.

3.7.4.1.5 Bonytail. The bonytail is endemic to the Colorado River Basin and was historically common to abundant in warmwater reaches of larger rivers of the basin from Mexico to Wyoming. The species experienced a dramatic, but poorly documented, decline starting in about 1950 (USFWS 2002a). Critical habitat has been designated for the species in portions of the Colorado, Green, and Yampa Rivers (USFWS 1994b).

Currently, no self-sustaining populations of bonytail are known to exist in the wild, and very few individuals have been caught anywhere. Releases of hatchery-reared adults into riverine reaches in the Upper Colorado River Basin have resulted in low survival, with no evidence of reproduction or recruitment.

Bonytail can live up to about 50 years (Rinne et al. 1986). Their habitat requirements are poorly understood (USFWS 2002a). On the basis of observations of closely related species, it is expected that bonytail in rivers probably spawn in spring over rocky substrates. It has been recently hypothesized that flooded bottomlands may provide important bonytail nursery habitat. Adult bonytail captured in Cataract, Desolation, and Gray Canyons were sympatric with humpback chub in shoreline eddies among emergent boulders and cobble, and adjacent to swift current (Valdez 1990).

The bonytail could occur only in portions of the Uinta Basin (Green River watershed) and in the Asphalt Ridge, Hill Creek, Pariette, Raven Ridge, Sunnyside, Tar Sand Triangle, and White Canyon STSAs (Green River and Colorado River watersheds).

3.7.4.1.6 California Condor. The California condor is an opportunistic scavenger that has been reintroduced into portions of its original range since nearing extinction in the 1970s. Prior to settlement by the pioneers in the mid-1800s, its range extended along the entire Pacific Coast from British Columbia to Baja California (USFWS 2006a). By the 1940s, the species distribution was limited to the coastal mountains of Southern California, with nesting sites located mainly in rugged, chaparral-covered mountains. Foraging was mostly in the foothills and grasslands of the San Joaquin Valley at that time. The total species size numbered only 22 in 1982, and in 1985, the USFWS decided to capture all remaining condors for safety and to start a captive breeding program (Behrens and Brooks 2000). After a captive breeding program, the first condors were released in 1992 in the Sespe Condor Sanctuary managed by the Hopper Mountain NWR (USFWS 2006b). At that time the population size was 63 individuals, all in captivity. Other reintroductions have taken place in south-central California and the Grand Canyon area of northern Arizona. The goal of the California Condor Recovery Plan completed in 1975 by the

USFWS and numerous other agencies and societies was to establish two populations each with about 150 individuals and a minimum of 15 breeding pairs (Behrens and Brooks 2000). As of April 2000, the California condor population had increased to 157, of which 62 were released into the wild. The total population is estimated to be about 200 individuals today (National Parks Conservation Association 2006).

The diet of California condors consists of carcasses of dead animals, including deer, cattle, marine mammals, and the remains of field-dressed game (USFWS 2006a). Rock pools are important as bathing sites that condors use after feeding.

California condors nest in caves or crevices in rock formations, or rarely in cavities of giant sequoia trees (*Sequoia giganteus*). Courtship and breeding occur from December through the spring months in California. Incubation by both parents lasts about 56 days. Chicks fledge at 2 to 3 months of age but they remain near the nest site for another 3 months. First flight occurs at about 6 months and juveniles remain with adult condors until the following year. Condors do not breed until about 6 years of age (USFWS 2006a).

Potential threats to the continued existence of the California condor include injury or death from collisions with power lines, human homes being built in mountainous areas occupied by the condors, consuming carrion containing pesticide residues, lead poisoning from eating carrion containing shot gun pellets, and illegal shooting (Behrens and Brooks 2000; USFWS 2006a). The large size of adults [about 10 kg (20–22 lb)] and long wingspan (about 9 ft) make the condor vulnerable to collisions with power lines, resulting in injury or death from electrocution. The range of the California condor includes the Tar Sand Triangle and White Canyon STSAs.

3.7.4.1.7 Canada Lynx. The Canada lynx is a medium-sized cat. It is federally listed as endangered only in the contiguous United States. Critical habitat has not been designated for this species. Threats to the Canada lynx include the loss and modification of habitat caused by logging, fire suppression, and fragmentation; isolation of suitable habitat; hunting and trapping resulting in severe population reductions; and increased human access into occupied habitat resulting in increased human disturbance. Competition with, and displacement by, the coyote and bobcat can also occur when these species move into occupied Canada lynx habitat (USFWS 1997b). The alteration of forests by human activities or the use of motorized vehicles, including snowmobiles, in lynx habitat may allow for the movement of coyotes into that habitat (USFWS 1998b).

The primary habitat of the Canada lynx for denning and shelter in western states is mature mesic coniferous forest, primarily composed of spruce and fir, with downed logs and windfalls, particularly those at montane and subalpine elevations (USFWS 1997b). Suitable denning stands are at least 1 ha (2.5 acres) in size, provide minimal human disturbance, and are near foraging habitat (USFWS 1998b). The snowshoe hare (*Lepus americanus*), the principal prey of the Canada lynx, prefers early successional forests with a shrubby understory. Thus, lynx depend on a mosaic of mature and early successional forest stands, a landscape habitat structure that was typically maintained by forest fires (USFWS 1997b). Lynx populations often rise and fall with those of the snowshoe hare. Other species, including red squirrels, other small mammals, and birds, are also taken by lynx. Populations in the contiguous United States have a greater reliance on these alternative prey species than northern populations (Ruediger et al. 2000). Canada lynx in shrub-steppe habitats prey on jackrabbits and ground squirrels.

Contiguous forest is important for connectivity between habitat blocks; however, dispersal may occur through nonforested habitats that are otherwise unattractive to lynx. Within these communities, riparian systems and relatively high ridge systems may be particularly important for landscape connectivity (Ruediger et al. 2000).

Although Canada lynx still occur in Colorado, Utah, and Wyoming, they are extremely rare (USFWS 1997b). In Utah, lynx are thought to occur in remote areas of the Uinta Mountains, particularly along the Wyoming border (USFWS 1998b). A self-sustaining resident population does not likely exist in Utah, but individuals may be present. Lynx habitat in Colorado is located within the Southern Rocky Mountains region, which also includes southeastern Wyoming, and is separated from the Northern Rocky Mountain region (which includes Utah) by natural barriers such as the Wyoming Basin and the Green River (USFWS 2000b). Few if any lynx remained in Colorado until reintroductions into the southwestern part of the state began in 1999.

The Canada lynx could occur in the Green River, Piceance, and Uinta Basins and in the vicinity of the Asphalt Ridge STSA.

3.7.4.1.8 Clay Phacelia. Clay phacelia is a winter annual forb that is endemic to Spanish Fork Canyon, Utah. It is found in fine-textured soil and fragmented shale of the Green River Formation. It grows on western- through southeastern-facing barren, precipitous hillsides in sparse pinyon-juniper and mountain brush communities, at elevations ranging from 1,840 to 1,881 m (UDWR 2011a).

The Clay phacelia was listed as federally endangered on October 29, 1978 (43 FR 44810), and a recovery plan was prepared on April 12, 1982 (USFWS 1982a). The goals of the recovery plan are to establish a self-sustaining population of 2,000 to 3,000 individuals on 120 acres of protected habitat, and to possibly establish at least one new population (Tilley et al. 2010).

Clay phacelia grows to be about 36 cm (14 in) tall and produces blue to violet bell-shaped flowers from June to August (Tilley et al. 2010; UDWR 2011a). Germination occurs in late summer and early fall (Tilley et al. 2010).

The population of Clay phacelia declined from nine to four known plants from 1977 to 1980, but by 1982 fencing had allowed the population to grow to about 200 individuals (CPC 2010). It currently occurs at four known sites; however, there are probably only two populations due to the close proximity of the sites (NatureServe 2011).

Threats to this population include natural extinction due to small population size and habitat destruction due to construction activities by the D&G RGW railroad company

(NatureServe 2011). The previous threat of grazing was largely eliminated by the construction of fencing.

The species could occur within or in the vicinity of development areas located in the Argyle Canyon STSA.

3.7.4.1.9 Clay Reed-Mustard. Clay reed-mustard is a perennial herbaceous plant that occurs in the Uinta Basin of Uintah County, Utah (UDWR 2006). It grows on clay soils rich in gypsum overlain with talus derived from shales and sandstones in the zone of contact between the Uinta and Green River geologic formations (USFWS 1994a). The UDWR characterized the species as growing on the Evacuation Creek Member of the Green River Formation, on substrates consisting of bedrock at the surface, on scree, and on fine-textured soils on north-facing slopes at elevations from about 1,440 to 1,770 m (4,724 to 5,807 ft) (UDWR 2006; NatureServe 2011).

Clay reed-mustard is known from only three populations and totals about 6,000 individuals. All populations occur on lands administered by the BLM within an area about 30 km (19 mi) wide from the west side of the Green River to the east side of Willow Creek in southwestern Uintah County (USFWS 1994a). This species occurs in mixed desert shrub communities. Flowering occurs from April to May, with seed production in May and June.

The clay reed-mustard was listed as threatened on January 14, 1992 (57 FR 1398). Subsequently, the USFWS prepared a recovery plan for the clay reed-mustard and two other related mustard species in 1994 (USFWS 1994a). One of the top priority goals defined in the recovery plan was to conduct inventories of suitable habitat for the clay reed-mustard. No additional information on the results of inventories that further describe any new populations or abundance data is known at this time.

Potential threats to the clay-reed mustard include a variety of ground-disturbing activities, such as oil and gas exploration and development (its entire habitat is underlain by oil shale), building stone removal, and OHV use (USFWS 1994a). The clay reed-mustard potentially occurs in the Uinta Basin and the Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, and Raven Ridge STSAs.

3.7.4.1.10 Colorado Hookless Cactus. The Colorado hookless cactus is one of three species of hookless cactus (genus *Sclerocactus*) that are federally listed as threatened under the ESA. This species is endemic to western Colorado, where it is currently believed to occur in the following four counties: Delta, Garfield, Mesa, and Montrose. The Colorado hookless cactus occurs primarily on alluvial benches (soils deposited by water) along the Colorado and Gunnison Rivers and their tributaries. This species generally grows on gravelly or rocky surfaces on river terrace deposits and lower mesa slopes. Individuals are more abundant on south-facing slopes. Elevations range from 1,400 to 2,000 m (3,900 to 6,000 ft) (USFWS 2010a).

There are two population centers of Colorado hookless cactus: (1) on alluvial river terraces of the Gunnison River near Delta, Colorado, to southern Mesa County, Colorado; and (2) on alluvial river terraces of the Colorado River and in the Plateau and Roan Creek drainages in the vicinity of DeBeque, Colorado. Between these two populations, this species has been documented at over 98 element occurrences totaling over 13,300 individuals. The current population estimate is over 19,000 plants within a total range of approximately 1,700 mi^2 (4,400 km^2) (USFWS 2010a).

The Colorado hookless has been protected under the ESA since 1979 (44 FR 58868). At that time, it was considered part of a single species (Uinta Basin hookless cactus [*S. glaucus*]). On September 15, 2009 (74 FR 47112), the USFWS officially recognized the taxonomic split of this species into three distinct species: *S. brevispinus* (Pariette cactus), *S. glaucus* (Colorado hookless cactus), and *S. wetlandicus* (Uinta Basin hookless cactus). The Colorado hookless cactus is listed uniquely under the ESA. Critical habitat for this species has not been designated.

Potential threats to the Colorado hookless cactus include the loss of habitat from energy development and agriculture. Oil and gas development is a large factor in the long-term conservation of the Colorado hookless cactus. While oil shale and tar sands development may be a threat to the Pariette cactus (*S. brevispinus*) and the Uinta Basin hookless cactus (*S. wetlandicus*), these activities are not likely to be a threat to the Colorado hookless cactus. Other activities that may affect the Colorado hookless cactus include gravel mining, off-road vehicle use, and the construction or upgrading of utility corridors (USFWS 2010a).

3.7.4.1.11 Colorado Pikeminnow. The Colorado pikeminnow is endemic to the Colorado River Basin. Colorado pikeminnow persist in the San Juan, Colorado, and Green Rivers and their tributaries; however, populations are severely reduced in all but the Green River (Platania et al. 1991; Tyus 1991; Osmundson and Burnham 1996). Critical habitat designated for Colorado pikeminnow occurs in the upper Colorado, Duchesne, Green, White, Gunnison, and Yampa Rivers. In designated river reaches, critical habitat includes both the river and its 100-year floodplain.

Colorado pikeminnow are long-lived fish (up to 40 years) and become sexually mature at 5 to 7 years of age (Vanicek and Kramer 1969; Hamman 1981; Tyus 1991). Adults are the most widely distributed of the pikeminnow life stages and move to spawning areas in spring. Eggs deposited on gravel spawning bars hatch within 5 to 7 days. Once they emerge, larvae are swept downstream, sometimes for long distances (Hamman 1981; Haynes et al. 1984; Nesler et al. 1988; Bestgen and Williams 1994; Bestgen et al. 1998). Larvae drift to relatively low-gradient river reaches where low-velocity, shallow, channel-margin habitats (e.g., backwaters) are common, and they remain there throughout the summer (Vanicek and Kramer 1969; Tyus and Haines 1991; Muth and Snyder 1995).

The Colorado pikeminnow is known to occur in portions of the Uinta Basin (Green, Duchesne, and White Rivers), Piceance Basin (White River), and in the vicinity of the Asphalt Ridge, Hill Creek, Pariette, Raven Ridge, Sunnyside, Tar Sand Triangle, and White Canyon STSAs (Green, San Juan, and Colorado Rivers).

3.7.4.1.12 Debeque Phacelia. The Debeque phacelia is a small summer annual that grows in only one area of western Colorado. Its distribution is within 10 mi of the town of DeBeque, south of South Shale Ridge and southwest of the Roan Plateau in Garfield County, Colorado (Center for Native Ecosystems 2006a). This species grows on sparsely vegetated, steep slopes in the mud cracks of chocolate brown or gray clay soil. No information was found on the time of flowering and seed set for this species.

Within its known range, there have been 27 occurrences of Debeque phacelia. Population size varies widely from year to year, most likely because of variation in precipitation between years. Its association with a very specific geologic substrate and habitat type make it unlikely for a range extension to occur (NatureServe 2011).

Potential threats to the Debeque phacelia include a variety of ground-disturbing activities, such as oil and gas drilling, oil shale development, and OHV use. Because it is an annual species, it depends on a healthy production of seeds in the top few centimeters of the soil to survive from year to year (Center for Native Ecosystems 2006a).

The Debeque phacelia occurs within the Piceance Basin in Garfield County, Colorado.

3.7.4.1.13 Dudley Bluffs Bladderpod. The Dudley Bluffs bladderpod is a perennial herbaceous plant that occurs in Rio Blanco County, Colorado. It is restricted to white shale outcrops of the Green River (Thirteen Mile Creek Tongue) and Uinta Formations, along areas exposed through the deepening of stream cuts at elevations of 6,000 to 6,700 ft (CPC 2006c; USFWS 1993b), and is found mostly on BLM-administered lands. All known occupied habitat is located on lands with oil shale resources.

The Dudley Bluffs bladderpod was listed as threatened on February 6, 1990 (55 FR 4152). The USFWS prepared a recovery plan in 1993 that called for habitat protection and inventory work on suitable habitat in the vicinity of known populations (USFWS 1993b).

Dudley Bluffs bladderpod is a small herb measuring only about 2 cm (1 in.) across and is difficult to see. It produces bright yellow flowers in dense clusters during April and May, with semispherical fruits forming in May or June (CPC 2006c). The total species distribution is believed to be in five populations on about 50 acres over a range of 10 mi (USFWS 1993b). The two largest known populations of about 10,000 individuals each were found growing together at the junction of Piceance Creek and Ryan Gulch about 2 mi north of Dudley Bluffs. The Center for Plant Conservation notes that there are seven known locations of Dudley Bluffs bladderpod in this same 10-mi-long area (CPC 2006c).

Potential threats to continued survival of the Dudley Bluffs bladderpod include oil shale development and other surface-disturbing activities. This species is so small that it was subjected to destruction during the annual monitoring of existing populations to such an extent that the USFWS suggested that the schedule and procedures for future monitoring activities by researchers be carefully assessed (USFWS 1993b).

The Dudley Bluffs bladderpod is known to occur in the Piceance Basin in Rio Blanco County, Colorado.

3.7.4.1.14 Dudley Bluffs Twinpod. The Dudley Bluffs twinpod is a small, herbaceous perennial that grows on white outcrop and steep slopes along exposed stream cuts. It is restricted to the Thirteen Mile Creek Tongue and Parachute Creek Member of the oil shale–bearing Green River Formation in Rio Blanco County, Colorado (USFWS 1993b). The Dudley Bluffs area also supports another federally listed threatened species (Dudley Bluffs bladderpod) in the same general area. Remnants of pinyon pine, Utah juniper woodlands, and cold desert shrub plant communities occur on mesas and along the slopes where Dudley Bluffs twinpod grows (USFWS 1993b; Colorado State Parks 2006b). The Dudley Bluffs area is designated as an ACEC. This designation means that the BLM will develop a habitat management plan that gives priority consideration to rare plant species (in this case) when considering the impacts of future activities approved by the BLM in the ACEC.

The USFWS listed the Dudley Bluffs twinpod as threatened on February 6, 1990 (55 FR 4152), and published a recovery plan in 1993 (USFWS 1993b). The recovery plan laid out objectives for future studies and protective measures for the species. The habitat for this species is on the surface of oil shale deposits that are suitable for either underground mining or surface mining of oil shale.

Dudley Bluffs twinpod is named for its distinct heart-shaped fruits. It flowers in May and June and produces fruits in June and July. There are five large populations on about 101 ha (250 acres) (USFWS 1993b). In total, about 10,000 individual plants occur in 12 sites 2 mi north of Dudley Bluffs near the junction of Piceance Creek and Ryan Gulch (CPC 2006d).

Potential threats to continued existence of the Dudley Bluffs twinpod include oil shale development activities and other surface disturbance (USFWS 1993b). The Dudley Bluffs twinpod occurs in the Piceance Basin in Rio Blanco County, Colorado.

3.7.4.1.15 Humpback Chub. The humpback chub is endemic to the Colorado River Basin. The species occurs primarily in relatively inaccessible canyon areas (Tyus 1998). The known historic distribution of the humpback chub includes portions of the main stem of the Colorado River and four of its tributaries, the Green, Yampa, White, and Little Colorado Rivers (USFWS 1990a). Critical habitat designated for humpback chub includes portions of the upper Colorado, Green, White, Gunnison, and Yampa Rivers.

Humpback chub complete their entire life cycle in canyons with deep water, swift currents, and rocky substrates (USFWS 2002b). Spawning occurs from April to June over cobble bars and shoals that are adjacent to low-velocity shoreline eddies as flow decreases from the annual spring peak (USFWS 2002b). Emerging humpback chub larvae do not drift long distances, but instead remain in the general vicinity of spawning areas (Valdez et al. 1982; Robinson et al. 1998; Chart and Lentsch 1999). Young require low-velocity shoreline habitats (including eddies and backwaters) that are more prevalent under base-flow conditions.

Humpback chubs mature in 2 to 3 years and may live 20 to 30 years (Valdez et al. 1992; Hendrickson 1993).

The humpback chub occurs in the vicinity of potential development areas in the Uinta Basin and the Asphalt Ridge, Hill Creek, Sunnyside, Tar Sand Triangle, and White Canyon STSAs.

3.7.4.1.16 Jones Cycladenia. The Jones cycladenia is a perennial herb that occurs in the canyonlands region of the Colorado Plateau (UDWR 2006). It grows on gypsum-laden soils derived from the Summerville, Cutler, and Chinle Formations that are shallow, fine textured, and mixed with rock fragments. This species typically is found in mixed desert shrub, pinyon-juniper, and Eriogonum-ephedra (wild buckwheat-mormon tea) plant communities at elevations from about 1,220 to 2,075 m (4,002 to 6,808 ft).

Jones cycladenia is a long-lived perennial that overwinters as belowground rhizomes. It grows to heights of 10 to 15 cm (4 to 6 in.) and produces pinkish-rose colored flowers from mid-April to early June (CPC 2006e). Seed production does not seem to be as important for reproduction as asexual means by sending up new plants from the roots.

Potential threats to this species include surface-disturbing activities such as oil and gas development activities and OHV use. The Jones cycladenia occurs in Emery, Garfield, Grand, and Kane Counties in Utah. It could occur in the vicinity of projects in the Uinta Basin and the Hill Creek, Pariette, P.R. Spring, and San Rafael STSAs.

3.7.4.1.17 Kendall Warm Springs Dace. The Kendall Warm Springs dace is endemic to a 984-ft (298-m) stream in Wyoming fed by the Kendall Warm Spring and emptying into the Green River. The stream is located on the east bank of the Green River in the northwestern Wind River Range, approximately 30 mi (48 km) north of Pinedale, Wyoming (USFWS 2007a; WGFD 2010b).

The Kendall Warm Springs dace was listed as federally endangered on October 13, 1970 (35 FR 16047). A recovery plan was created in 1982 (USFWS 1982b) with a goal of maintaining a reproducing population at or above existing levels by protecting the Kendall dace and 158 acres (64 ha) designated as essential habitat in 1977.

A single population of the dace exists. This population was estimated to be between 200,000 and 500,000 individuals in 1937 (NatureServe 2011). Monitoring in 2005 suggested that the population had remained relatively stable; however, 2007 data suggested a population decline, possibly due to a recent drought (USFWS 2007a).

Adults range in size from 0.9 to 2.1 in. (2.3 to 5.3 cm) and are dull olive green in color. Adults can be found in the main current of the stream, while fry are most often found in small shallow pools in beds of aquatic vegetation (USWFS 2007a). Larval fish are unable to swim in the faster stream currents and many are swept over a 13-ft (4-m) waterfall into the Green River (at a rate of 75/day) (Gryska and Hubert 1997). The dace are reproductively active throughout the year (Gryska and Hubert 1997).

The USFWS identified oil and gas development as the highest threat to the Kendall Warm Springs dace population. The management area that contains the Kendall Warm Springs dace and the springs' potential recharge area is predicted to have one of the highest potentials for projected oil and gas development, and this type of development could potentially affect the stream water quantity and/or quality (USWFS 2007a). Additional threats include contamination of water, illegal collection, introduction of exotic fish, and water level lowering (NatureServe 2011).

This species is endemic to Sublette County, Wyoming, which also contains the Green River Oil Shale Basin. However, habitat for this species (Kendall Warm Spring and its outflow) is approximately 60 mi (96 km) north of the Green River Basin and it is not likely for the species to occur in the vicinity of the development areas located in the Green River Basin.

3.7.4.1.18 Last Chance Townsendia. The last chance townsendia is a perennial herb that occurs in Emery, Sevier, and Wayne Counties in Utah (UDWR 2006). It grows on barren, silty, silty clay, or gravelly clay soils of the Mancos Shale Formation at elevations ranging from 1,686 to 2,560 m (5,531 to 8,399 ft). Most plants grow on soils derived from a shale lens with a fine silty texture and high alkalinities, and are distributed as isolated pockets (USFWS 1993c). This species is found in desert shrub and pinyon-juniper communities.

The last chance townsendia flowers from April to May, and fruiting occurs in May and June (USFWS 1993c). Fifteen populations were known in 1993, each with a range numbering from 6 to about 2,000 individuals over an area of about 1 acre. The total population as of 1994 was estimated at 6,000 individuals. No recent information was available on population numbers within the known distribution range. Most of the populations of the last chance townsendia are on BLM-administered lands and in Capitol Reef National Park (USFWS 1993c). All known populations are in a band less than 5 mi wide and 30 mi long in southwestern Emery County and southeastern Sevier County, Utah.

The USFWS prepared a recovery plan in 1993 (USFWS 1993c). The last chance townsendia was listed as threatened on August 21, 1985 (50 FR 33734). It was given a rating with a high degree of threat and low recovery potential. The recovery plan set goals of maintaining a documented population of 30,000 individuals and maintaining 20 populations with at least 500 individuals each. The plan also called for formal land management designations on known populations to ensure the existence of long-term habitat.

Potential threats to continued existence of the last chance townsendia include disturbance or loss of habitat from mineral and energy development, road construction, and trampling by livestock. Future coal mining at the Emery coal field could eliminate populations if protective measures are not in place. The last chance townsendia could occur in the vicinity of the San Rafael STSA.

3.7.4.1.19 Maguire Daisy. The Maguire daisy is a small (up to 5 in. in height) perennial herb that occurs on sand- and detritus-weathered surfaces of the Navajo, Wingate, and Chinle Sandstone Formations in mountain shrub, Douglas-fir, ponderosa pine, and juniper woodland plant communities at elevations of 1,600 to 2,500 m (5,249 to 8,202 ft). Plants grow on slickrock crevices, ledges, and bottoms of washes. It is found in locations in Emery, Garfield, and Wayne Counties in Utah (UDWR 2006).

The Maguire daisy was originally listed as endangered but was downlisted to threatened status in 1996 on the basis of DNA evidence of what was thought to be two separate varieties (CPC 2006f). At the time of reclassification to threatened, the total population was believed to total about 3,000 individuals from 12 locations within the three-county area that composed its known distribution.

Flowering occurs from mid-June through July. Plants typically have one to five flower heads with white to pinkish ray flowers around a yellow center that grows from a branched woody base (BLM 2006f). Seed formation likely occurs in July and August, although no specific information on the time of seed shed was found.

Potential threats to continued existence of the Maguire daisy include loss of habitat and genetic viability, trampling by hikers and livestock, OHVs, and mineral and energy exploration and development (CPC 2006f). The Maguire daisy could occur in the vicinity of the San Rafael STSA.

3.7.4.1.20 Mexican Spotted Owl. The Mexican spotted owl occurs from southern British Columbia, Canada, to central Mexico. It is a rare permanent resident in the southern and eastern parts of Utah on the Colorado Plateau (UDWR 2006). The primary habitat of the spotted owl in Utah is steep rocky canyons, although forested areas are also important habitat in Utah and elsewhere in the spotted owl's range (UDWR 2006). The spotted owl is most common in closed canopy forests in steep canyons with uneven-aged tree stands with high basal area, with an abundance of snags and downed logs. The State of Utah shows the Mexican spotted owl distribution to include sizeable portions of San Juan, Wayne, Garfield, Kane, and Iron Counties in Utah, as well as a small area of extreme eastern Carbon County and extreme east-central Uintah County (UDWR 2006). The latter area is located near the Raven Ridge STSA. In a study of Mexican spotted owl home range size in southern Utah, Willey and Van Riper (2007) found that the average home range size of spotted owls varied by season. The authors found that during the breeding season, the average home range size for each owl was approximately 545 ha; during the nonbreeding season, the average home range size was approximately 1,032 ha.

The Mexican spotted owl was listed as threatened on March 16, 1993 (58 FR 14248). Critical habitat was designated on June 5, 1995 (63 FR 14378), but several court rulings resulted in the USFWS removing the critical habitat designation on March 25, 1998 (63 FR 14378). In March 2000, the USFWS was ordered by the courts to propose critical habitat; this resulted in the current designation, which includes 4.6 million acres in Arizona, Colorado, New Mexico, and Utah on federal lands (USFWS 2006e). A recovery plan for the Mexican spotted owl was published in December 1995 (USFWS 1995a). At the time of federal listing in 1993, the total population of Mexican spotted owls was estimated at 2,100.

A total of 2,252,857 acres in five areas of southern Utah were designated as critical habitat. Critical habitat within the study areas includes two parcels in Utah designated as CP-14 and CP-15. Area CP-15 is along the west side of the Green River and includes land north and south of the border between Carbon and Emery Counties (USFWS 2006e). Area CP-14 is farther south and includes lands on both sides of the Colorado River in portions of San Juan, Wayne, and Garfield Counties. Designated critical habitat and a Protected Activity Center (PAC) for the Mexican spotted owl also occur within the Tar Sands Triangle STSA.

The Mexican spotted owl feeds mainly on rodents but also consumes rabbits, birds, reptiles, and insects. Nest sites are in trees (typically those with broken tops), tree trunk cavities, and cliffs along canyon walls (BLM 2006f). Breeding takes place in the spring (March), with egg-laying in late March or early April. After a 30-day incubation period, hatching occurs and fledging takes place in 4 to 5 weeks. The young depend on the adults for food in the summer and eventually disperse from the nesting area in the fall (USFWS 2006f).

Potential threats to the Mexican spotted owl include habitat loss from logging of old growth forest, disturbance of owls by recreational use on federal lands, overgrazing, loss of habitat and disturbance of owls from road development within canyons, and habitat loss from catastrophic fires.

Within potential project areas, the Mexican spotted owl is likely to occur only in southern Utah (UDWR 2006). All areas in Colorado where the species occurs and where critical habitat has been designated are located well south of development areas (e.g., >160 km [100 mi]). The Mexican spotted owl could occur in the vicinity of the Raven Ridge, Tar Sand Triangle, and White Canyon STSAs. The range is within 5 km (3 mi) of the Uinta Basin.

3.7.4.1.21 Navajo Sedge. The Navajo sedge is a perennial plant that is restricted to shady seep pockets or alcoves in hanging garden habitats in Navajo Sandstone at elevations ranging from about 1,150 to 1,820 m (1,150 to 5,971 ft) (UDWR 2006). These habitats are characteristic of the deep, sheer-walled canyons of the Colorado Plateau. The Navajo sedge is known from San Juan and Kane Counties in Utah and on the Navajo Indian Reservation in Arizona (Coconino, Navajo, and Apache Counties) (AZGFD 2006; CPC 2006g).

The Navajo sedge was federally listed as threatened on May 8, 1985, and critical habitat was described also in that listing (50 FR 10370). A recovery plan was approved on September 24, 1987. Critical habitat is on the Navajo Indian Reservation in Coconino County; the habitat contains three springs near Inscription House Ruins (50 FR 19370).

The Navajo sedge grows to a height of 25 to 40 cm (10 to 16 ft) and has grasslike leaves that droop downward. Flowers are arranged in spikes, with two to four spikes per stem, and develop during late June and July; seeds are produced in July and August (CPC 2006g; UDWR 2006).

Potential threats to continued existence of the Navajo sedge include groundwater pumping, water diversion projects, and livestock grazing (AZGFD 2006). Sheep grazing and groundwater pumping are considered to be the greatest threats to the species in Utah (UDWR 2006).

The Navajo sedge occurs in San Juan County, Utah, with a very small portion of its range in extreme northern Kane County (UDWR 2006); these populations do not occur in the vicinity of any potential oil shale or tar sands development.

3.7.4.1.22 Parachute Beardtongue. The Parachute beardtongue is a perennial herbaceous mat-forming species that grows on steep, oil shale outcrop slopes of white shale talus at 8,000 to 9,000 ft in elevation on the southern escarpment of the Roan Plateau (USFWS 2006h) in Garfield County, Colorado. It is known from six locations that occupy a total of about 200 acres. The Parachute beardtongue is restricted to the Piceance Basin and is found only in the Parachute Creek Member of the Green River Formation.

There are only four populations considered viable by the Colorado Rare Plant Technical Committee, and three of these are on land owned by an energy company. The other population occurs on BLM land (USFWS 2006h). Potential threats to this species include ground-disturbing activities, such as oil shale development, recreational use, and natural gas development (Center for Native Ecosystems 2006c; NatureServe 2011). The Parachute beardtongue occurs in Garfield County, Colorado, in the southern portion of the Piceance Basin.

3.7.4.1.23 Pariette Cactus. Pariette cactus is endemic to highly saline and alkaline soils and is restricted to clay badlands within a single area a few miles across in Duchesne County, Utah (NatureServe 2011). It occurs on exposed clay hills and in saltbush and sagebrush flats at elevations ranging from 1,400 to 1,500 m in areas that are dominated by *Atriplex*, *Chrysothamnus*, and *Tetradymia* species (USFWS 2010b).

The Pariette cactus was listed as threatened on September 15, 2009 (74 FR 47117). It was previously part of the complex of *Sclerocactus glaucus* listed as threatened (44 FR 58868) in 1979, but this complex was split into three distinct species in 2009 and all three species were listed as threatened (74 FR 47117). A recovery plan for the Pariette cactus was created on April 14, 2010 (USFWS 2010b).

The Pariette cactus is a barrel-shaped cactus that ranges from 2.5 to 8 cm tall and produces pink bell-shaped flowers and short, barrel-shaped, reddish or reddish grey fruit (USFWS 2011). Ribs running along the stems have small, cushion-like areas with hooked spines (USFWS 2010b).

The total population size of the Pariette cactus was estimated to be around 12,000 individuals in 2007. These individuals are all part of a single population within a 29,000 ha area (USFWS 2010b).

Some potential threats to the Pariette cactus include mineral and energy development, illegal collection, recreational OHV use, genetic swamping from the more widespread *S. wetlandicus*, and grazing. All of the potential Pariette cactus habitat on BLM lands has been leased for oil and gas development (USFWS 2010b). The USFWS has indicated that this species could be affected by oil shale and tar sands development activities (USFWS 2010a). The species could occur within or in the vicinity of development areas located in the Uinta Basin and the Hill Creek, Pariette, P.R. Spring, and Sunnyside STSAs.

3.7.4.1.24 Razorback Sucker. The razorback sucker, endemic to the Colorado River Basin, was once widely distributed in warmwater reaches of larger rivers of the basin from Mexico to Wyoming (Muth et al. 2000). Today, the species is one of the most imperiled fishes in the Colorado River Basin and exists naturally as only a few disjunct populations or scattered individuals (Minckley et al. 1991; Bestgen et al. 2002). Although the largest riverine population is in the middle Green River (Tyus 1987; Modde et al. 1996), the most recent estimate indicates that this population has been declining, that it has little or no recruitment, and that only about 100 individuals remain (Bestgen et al. 2002). The lack of recruitment has been attributed mainly to the cumulative effects of habitat loss and modification caused by water and land development and predation on early life stages by non-native fishes (Muth et al. 2000).

Habitats used by adult razorback suckers include deeper runs, eddies, backwaters, and flooded off-channel habitats in spring; runs and pools over submerged sandbars in summer; and low-velocity runs, pools, and eddies in winter (Tyus 1987; Osmundson and Kaeding 1989; Valdez and Masslich 1989; Tyus and Karp 1990; Modde 1997; Modde and Wick 1997; Modde and Irving 1998). Young razorback suckers require nursery environments with quiet, warm, shallow water, such as tributary mouths, backwaters, or inundated floodplain habitats (Taba et al. 1965; Gutermuth et al. 1994; Modde 1996, 1997; Muth et al. 1998).

Razorback suckers make annual spawning runs to specific river areas (Minckley 1973). Larval razorback suckers emerge from spawning substrates and are transported downstream into off-channel nursery habitats with quiet, warm, shallow water (e.g., tributary mouths, backwaters, and inundated floodplain habitats). The most important of these habitats are located in the middle Green River within Ouray NWR. Larvae have recently been found in the lower reaches of the White River in Utah, approximately 5 mi upstream from the confluence with the Green River. This indicates that adults are also present during some periods and that successful reproduction is occurring in the White River.

The razorback sucker occurs in the vicinity of the Uinta Basin (Duchesne and Green Rivers), Piceance Basin (White River), and the Asphalt Ridge, Hill Creek, Pariette, Raven Ridge, Sunnyside, Tar Sand Triangle, and White Canyon STSAs (Green and Colorado Rivers). Critical habitat designated for razorback sucker occurs in the upper Colorado, Duchesne, Green, and White Rivers. In designated river reaches, critical habitat includes both the river and its 100-year floodplain.

3.7.4.1.25 San Rafael Cactus. The San Rafael cactus is a perennial species that grows on fine-textured soils rich in calcium derived from the Carmel Formation and the Sinbad Member of the Moenkopi Formation. It occurs on benches, hilltops, and gentle slopes in open pinyon-juniper woodland and mixed desert shrub grassland communities at elevations ranging from 1,450 to 2,080 m (4,757 to 6,824 ft) (UDWR 2006).

The USFWS listed the San Rafael cactus as endangered on September 16, 1987 (52 FR 349917). A recovery plan was prepared in 1995 (USFWS 1995b). A major focus of the recovery plan was to conduct additional surveys in Emery County, Utah, in an attempt to identify new populations. Identifying at least five separate populations that are viable at the population level and maintaining these populations were set forth as important goals to realize recovery of the species.

The San Rafael cactus is extremely small, growing to a height of only about 1.5 to 2.0 in. and has a diameter ranging from 1.2 to 3.8 in. (USFWS 1995b). Flowering occurs during April and May, and fruiting occurs in May and June.

In 1995, the total size of the San Rafael cactus population was estimated to be about 20,000, located in three separate populations, all within the San Rafael Swell north of the San Rafael River in Emery County (USFWS 1995b; BLM 2006f). The estimated population had dropped to 6,000 in 1998.

Potential threats to the continued existence of the San Rafael cactus include habitat destruction from OHVs, trampling by hikers and livestock, oil and gas exploration activities, and exploration and mining for gypsum and other minerals (USFWS 1995b).

The San Rafael cactus occurs in Emery County, Utah, and a small area in the northern extreme of Wayne County (UDWR 2006). There is a potential for the species to be present in the vicinity of the San Rafael STSA.

3.7.4.1.26 Shrubby Reed-Mustard. Shrubby reed-mustard is a perennial herb that is endemic to semibarren white shale layers of the Evacuation Creek Member of the Green River Formations in the Uinta Basin of Utah (NatureServe 2011; UDWR 2006). It grows in xeric, thin, fine-textured soils that overlay oil shale fragments at elevations ranging from 1,555 to 2,042 m (5,101 to 6,699 ft) (UDWR 2006). Plant communities where the shrubby reed-mustard occurs are mixed desert shrub and pinyon-juniper woodlands. The primary land use in the range of the shrubby reed-mustard is winter sheep grazing.

Currently, there are eight known populations totaling about 3,000 individual plants (NatureServe 2011). In 1994, the USFWS reported only three known populations (USFWS 1994a). The entire range of the shrubby reed-mustard is underlain by oil shale and conventional oil and gas deposits. It has a clump-forming growth form and produces yellow flowers during May and June (NatureServe 2011).

The shrubby reed-mustard was listed as endangered on October 6, 1987. A recovery plan for this species and two closely related mustard species was prepared by the USFWS (1994a). Some disagreement remains over the taxonomy of this species; some taxonomists consider it the sole member of the genus *Glaucocarpum* (NatureServe 2011).

Potential threats to continued existence of the species include ground-disturbing activities such as oil shale development, grazing, habitat destruction from collection of building stone, and oil and gas exploration and development (NatureServe 2011). The shrubby reed-mustard could occur within or in the vicinity of development areas in the Uinta Basin and the Hill Creek, Pariette, P.R. Spring, and Sunnyside STSAs (UDWR 2006).

3.7.4.1.27 Southwestern Willow Flycatcher. The southwestern willow flycatcher is a small, neotropical migrant bird. Its breeding range includes the southern portion of Utah, southwestern Colorado, western Texas, New Mexico, Arizona, southern Nevada, southern California, and northwestern Mexico (USFWS 2002d). It depends on riparian vegetation for nesting, foraging, and migratory habitat. The southwestern willow flycatcher historically nested primarily in willows, with a scattered overstory of cottonwoods. It now also nests in non-native tamarisk and Russian olive (USFWS 1997a). Nesting habitat is characterized by dense riparian shrubs, about 4 to 7 m (13 to 23 ft) tall, often with a high percentage of canopy cover, sometimes with a scattered overstory of cottonwood. Preferred nesting habitat seems to be associated with standing water, exposed sand bars, or nearby fluvial marshes. The southwestern willow flycatcher forages for insects within and occasionally above riparian vegetation.

Once common along rivers of the Southwest, the southwestern willow flycatcher population size is estimated to be between 1,200 and 1,300 pairs (USFWS 1997a). Population declines have been attributed to the loss, degradation, and fragmentation of its riparian habitat, and parasitism by brown-headed cowbirds (*Molothrus ater*). Suitable riparian habitats tend to be rare and widely separated. Impacts on its riparian habitat have resulted from urban, recreational, and agricultural development; fires; water diversion and impoundment; channelization; livestock grazing; and displacement of native shrubs by exotic species (USFWS 1997a).

The southwestern willow flycatcher is known to occur only in portions of the Uinta Basin and in the vicinity of the P.R. Spring, San Rafael, Tar Sand Triangle, and White Canyon STSAs. Critical habitat has not been designated for this species in the vicinity of potential development areas.

3.7.4.1.28 Uinta Basin Hookless Cactus. Recently, the USFWS proposed recognition of three separate, but related, species that had been collectively referred to as the Uinta Basin hookless cactus (72 FR 53211). These species include the Pariette cactus (*Sclerocactus brevispinus*; found only in the Pariette Draw in the central Uinta Basin in Utah), *S. wetlandicus* (found in much of the Uinta Basin in Utah; proposed common name Uinta Basin hookless cactus), and *S. glaucus* (endemic to western Colorado; proposed common name Colorado hookless cactus).

The Uinta Basin hookless cactus is a perennial species that occurs in Carbon, Duchesne, and Uintah Counties in Utah (USFWS 2010c). In Utah it is found growing on river benches, valley slopes, and rolling hills along the Duchesne River, Green River, and Mancos Formations. The Uinta Basin hookless cactus grows on xeric, fine-textured soils that have cobbles and pebbles on the surface at elevations from 1,360 to 2,000 m (4,461 to 6,562 ft) (UDWR 2006) and is typically found in salt desert shrub and pinyon-juniper plant communities. It is most abundant on south-facing slopes of about 30% grade. Other common plant species in communities where the Uinta Basin hookless cactus occurs include shadscale (*Atriplex confertifolia*), galleta (*Hilaria jamesii*), black sagebrush (*Artemisia nova*), and Indian rice grass (*Stipa hymenoides*) (USFWS 1990b).

The Uinta Basin hookless cactus flowers in April and May; fruiting occurs in May and June (USFWS 1990b). Seeds are typically small and are spread by gravity, water flow, and insects or birds. Total population numbers in Utah for the Uinta Basin hookless cactus are believed to be approximately 30,000 individuals; current population total numbers in Colorado are estimated at 10,000 individual plants.

Potential threats to the continued existence of this species include ground-disturbing activities, such as oil and gas exploration, drilling and removal, oil shale and tar sands mining, sand and gravel quarrying, building stone collection and quarrying, OHV use, and road construction, as well as parasitism by termite and beetle larvae and moderate grazing by livestock resulting in trampling of cactus (USFWS 1990b; NatureServe 2011; UDWR 2006). The USFWS has indicated the potential threat to this species from oil shale and tar sands development (USFWS 2010c).

Within potential development areas, the Uinta Basin hookless cactus occurs mostly in Uintah County, Utah, with a smaller portion of the distribution range in eastern Duchesne County, south of the Duchesne River, and in southeastern Duchesne County and Carbon County along Nine Mile Creek. It occurs in Uintah County along the Green and White Rivers and on the Ouray NWR just north of the town of Ouray (USFWS 1990b). On the basis of these distributions, the species could occur within or in the vicinity of development areas in the Piceance and Uinta Basins and the Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, Raven Ridge, and Sunnyside STSAs.

3.7.4.1.29 Utah Prairie Dog. The Utah prairie dog occurs in grasslands, level mountain valleys, and in areas with deep well-drained soils with low-growing vegetation that allows for good visibility. It is one of three prairie dog species found in the state of Utah and occurs in the southwestern portion of the state (UDWR 2006). Utah prairie dogs are diurnal herbivores that live in colonies and spend much of their time underground. They are inactive or torpid during the winter months in severe winter weather (NatureServe 2011). Adults emerge from mid-March to early April. Breeding occurs in the spring, and young emerge from the burrows during May and early June. Adults are often dormant from mid-July to mid-August and are not often seen above ground during this period. Juveniles enter dormancy during October and November.

The Utah prairie dog feeds primarily on grasses and various seeds and flowers of shrubs and insects when available (NatureServe 2011). Common plant species consumed include alfalfa, leafy aster, European glorybind, and wild buckwheat seeds. Home range size of the Utah prairie dog varies from 1.2 to 8.2 ha (3 to 20 acres) and depends on habitat quality (NatureServe 2011).

The population size of the Utah prairie dog has varied considerably during historic times. In 1920, and prior to programs to control the Utah prairie dog, the total population was estimated at 95,000. Shooting and poisoning by ranchers, and likely periodic reductions from the plague, led to a decrease in population size, which was estimated at about 3,700 by 1984. By the spring of 1989, the adult population reached 9,200. The USFWS in its Report to Congress (as cited in NatureServe 2011) reported that this size was considered at risk of a population crash from a plague outbreak.

The Utah prairie dog was first listed as endangered in 1973. In 1984, it was reclassified as threatened by the USFWS and is currently the subject of a 5-year status review to determine whether listing the species as endangered is warranted. A recovery plan was prepared (USFWS 1991b) that described the current extent of existing populations and laid out management goals for continued survival of the species. A major goal was to improve the chances of long-term survival of the species in the following areas: West Desert in southern Beaver and Iron Counties, Paunsaugunt in western Garfield County, eastern Iron County and extreme northwestern Kane County, and the Awapa Plateau that extends from Sevier County southward through western Wayne and Piute Counties into northern Garfield County. The recovery plan also described plans to transplant Utah prairie dogs to unoccupied habitats and defined procedures to monitor transplants.

The 90-day finding on the petition to reclassify the Utah prairie dog from threatened to endangered (USFWS 2007b) acknowledged that impacts on Utah prairie dogs can occur as a result of many of the factors listed by the petitioners (e.g., loss of land conversion; livestock grazing; roads and OHV use; oil, gas, and mineral development; seismic exploration; and sylvatic plague). However, the USFWS determined that the petition did not identify or present substantial new information indicating that the level of threats to the species had changed significantly since its reclassification to threatened in 1984. The agency further stated that the current number of active colonies and the number of Utah prairie dogs counted in 2005 (5,381) continues to be within the range of observed variation since 1976. Prairie dog counts have historically not included significant populations located on tribal land, where some of the best prairie dog habitat is located (Hyde 2011).

The Utah prairie dog occurs in Wayne and Garfield Counties in Utah. STSAs in these counties are in the northeastern and central portions of Garfield County and in southeastern portions of Wayne County. These areas are all east of known populations of the Utah prairie dog, on the basis of information presented in the recovery plan (USFWS 1991b).

3.7.4.1.30 Ute Ladies'-Tresses. The Ute ladies'-tresses is a perennial orchid. Flowering generally occurs from late July through August. Ute ladies'-tresses appears to have a very low reproductive rate. Individuals may require 10 years to reach reproductive maturity and thereafter do not flower every year. The percentage of flowering individuals in a population can range from 23 to 79% (Ward and Naumann 1998).

Ute ladies'-tresses typically occurs on sandy or loamy alluvial soils mixed with gravels in mesic to very wet meadows along streams and abandoned stream meanders, riparian edges, gravel bars, and near springs, seeps, and lakeshores, generally at elevations ranging from 1,300 to 2,000 m (4,265 to 6,561 ft) (USFWS 1992; NNHP 2001; UDWR 2002; NatureServe 2011). Threats to populations of Ute ladies'-tresses include modification of riparian habitats by urbanization, stream channelization and other hydrologic changes, conversion of lands to agriculture and development, heavy summer livestock grazing, and hay mowing. Most populations are small and vulnerable to extirpation by habitat changes or local catastrophic events (USFWS 1992). Many appear to be relict populations. Several historic populations in Utah and Colorado appear to have been extirpated.

The Ute ladies'-tresses is known to occur within Duchesne, Garfield, Uintah, and Wayne Counties, Utah, and could, therefore, occur within or in the vicinity of development areas located in the Uinta Basin and the Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, and Raven Ridge STSAs.

3.7.4.1.31 Whooping Crane. Whooping cranes are currently listed as endangered except where nonessential experimental populations exist. In the United States, the whooping crane (*Grus americana*) was listed as threatened with extinction in 1967 and endangered in 1970 (USFWS 1967, 1970); both listings were "grandfathered" into the Endangered Species Act of 1973. Critical habitat for the whooping crane was designated in 1978 (USFWS 1978). Migration areas within the United States that are designated as critical habitat include the Platte River between Lexington and Denman, Nebraska; Cheyenne Bottoms State Waterfowl Management Area and Quivira NWR, Kansas; and Salt Plains NWR, Oklahoma. The Aransas NWR, in Texas, and vicinity have been designated by the USFWS as critical wintering grounds for the conservation of the species (USFWS 1978). A species recovery plan was finalized in 2007 (CWS and USFWS 2007).

The whooping crane could only occur as a rare migrant in the study area. It is considered extirpated from Wyoming and Utah, and populations west of the Rocky Mountains are considered experimental and nonessential (USFWS 1997c).

Whooping crane populations declined from about 1,400 in 1860 to a low of 16 individuals in 1941 (Whooping Crane Conservation Association 2006). Captive breeding, reintroductions, and habitat protection by participants in the Whooping Crane Recovery Program have enhanced the species' chances of long-term survival. The number of whooping cranes has increased about 4% per year, with about 470 individuals in existence at the end of 2004 (Cornell Laboratory of Ornithology 2006), including 213 in the wild. An experiment to establish a second breeding population in Gray's Lake NWR in southeastern Idaho was initiated in 1975. Whooping crane eggs were transferred to nests of sandhill cranes, which were intended to be used as foster parents that would raise the whooping cranes and lead them to the sandhill's wintering habitat at Bosque del Apache NWR in south-central New Mexico. The experiment was unsuccessful because whooping cranes failed to bond with each other but instead paired with sandhill cranes. The program was discontinued in 1989 (Cornell Laboratory of Ornithology 2006).

Subsequent experiments to reintroduce whooping cranes involved the use of ultralight aircraft. In 1996, researchers successfully led imprinted sandhill cranes from their summer breeding habitat in southern Ontario to wintering grounds in Virginia. Sandhill cranes were used in the initial experiments to determine the feasibility of using ultralight aircraft to lead imprinted birds to wintering grounds. In 1997, sandhill cranes from Idaho that were imprinted on an ultralight aircraft and four whooping cranes flew to the Bosque del Apache NWR. The whooping cranes survived the winter and returned on their own to Idaho the following spring (Whooping Crane Conservation Association 2006). During their spring and fall migrations, these whooping cranes and any offspring could pass over oil shale and STSA development areas of eastern Utah and western Colorado.

Most of the breeding habitat for the whooping crane is located in the Wood Buffalo National Park and areas immediately adjacent to the park boundaries in the Northwest Territories of Canada. Whooping cranes are known to start nesting, defined as laying eggs, as early as 3 years of age, although the average age of first egg-laying is 5 years. Experienced pairs arrive at WBNP in late April and begin nest construction in marshes. Egg-laying occurs from late April to mid-May and incubation varies from 29 to 31 days. In 25 years of clutch size data gathered between 1966 and 1991, the typical clutch contained 2 eggs (90.8 percent of 514 clutches observed), and 1 egg was found in 43 clutches (8.6 percent). Breeding territories are usually more than 0.6 mi (1 km) apart. Banding studies showed that pairs nest in the same territories year after year; several pairs were observed using the same areas for 22 consecutive years. Activities of breeding pairs, family groups, and chicks occur within the same territories until the chicks are a few months old. Immature cranes typically stay near adult pairs near the territory margins. Nesting territories vary in size with an average size of 2.5 mi^2 (4.1 km^2). Whooping cranes will re-nest if eggs are lost or destroyed during the first half of the incubation period. Research has shown that typically only one of the two hatched chicks are fledged, and fewer than 10% of fledged pairs reach Aransas NWR at the end of their initial migration (CWS and USFWS 2007).

Grain fields, shallow lakes, and saltwater marshes compose the typical winter habitat. Grain fields, mud flats around reservoirs, and marshes are also important habitats during stopovers in the spring and fall migrations. Whooping cranes consume a variety of plants and animals, including mollusks, crustaceans, insects, fish, frogs, and waste grain in agricultural fields (Cornell Laboratory of Ornithology 2006).

Migration of whooping cranes begins in late March as individual birds and flocks depart the Texas coastal area. Most cranes arrive at the Wood Buffalo National Park by mid-April and initiate breeding activity between that time and early May (CWS and USFWS 2007). Recent whooping crane observations during the spring of 2008 were summarized by Martha Tacha of the USFWS, Grand Island, Nebraska (Stehn 2008). Tacha reported that the winter flock was composed of 266 cranes and that the first individuals observed north of Aransas NWR were in Kansas on March 25.

Potential threats to the continued existence of the whooping crane are predation, collisions with power lines, and shooting by hunters who mistakenly identify them as sandhill cranes, which can be legally hunted in some states. A concerted effort is being made by the International Whooping Crane Recovery Team to establish new breeding populations.

Migrating whooping cranes appear to avoid areas near human residences and prefer areas with good visibility. Austin and Richert (2001) found that most locations where whooping cranes have been observed in Nebraska were more than half a mile from any human structures or developments. Most were more than a third of a mile from the nearest power or phone lines, and about half of all the roost sites and two-thirds of the foraging sites had unobstructed visibility for more than a quarter mile and were associated with river widths greater than 700 ft. Visibility and adequate distance from human activity may be important whooping crane requirements during the spring and fall migration periods. They also need access to wetlands for both foraging and nocturnal roosting; individuals prefer to roost in shallow water, well away from heavy shoreline or island vegetation.

Within the study area, the whooping crane could only occur as a rare migrant during the spring and fall migration periods. No breeding populations are known to occur in the study area.

3.7.4.1.32 Winkler Cactus. The Winkler cactus is a small cactus that grows on fine-textured, mildly alkaline soils derived primarily from siltstones and shales of the Dakota Formation and from the Brushy Basin Member of the Morrison Formation (BLM 2006f; UDWR 2006). It occurs on benches, hill tops, and gentle slopes (most commonly on south-facing slopes) on barren areas in salt desert shrub communities at elevations of 1,450 to 2,010 m (4,757 to 6,594 ft).

The Winkler cactus was listed as threatened on August 20, 1998 (161 FR 44587). The recovery plan for this species was published together with a related species, the San Rafael cactus (USFWS 1995b). In 1998, the USFWS estimated the total size of the Winkler cactus population at 20,000 individuals in four populations in Wayne and Emery Counties, Utah. Three of the four populations are distributed in an arc that extends from Notom in central Wayne County to the vicinity of Last Chance Creek in southwestern Emery County, Utah. The fourth population is located near Ferron, Utah, in western Emery County. Most populations occur on scattered sites along an area about 36 mi long and 0.3 mi wide. About two-thirds of the populations occur on BLM-administered land, and the remaining populations occur on Capitol Reef National Park. Its distribution range converges with that of the San Rafael cactus in Emery County (63 FR 44587).

Flowering of the Winkler cactus occurs from May to June; fruit formation occurs in June and July. Late winter and spring moisture conditions and temperature determine the actual time of flowering and fruit production in any given year.

Potential threats to the Winkler cactus include illegal collecting and loss of habitat or damage to individuals from trampling by hikers, mining activities, and oil and gas development (USFWS 1995b; BLM 2006f). Within the study area, the range of the Winkler cactus occurs about 10 km (6 mi) to the west of the San Rafael STSA in central Emery County. The population in Wayne County is located in the central portion of the county and about 70 km (43 mi) to the west of the Tar Sand Triangle STSA located in the southeastern part of the county (UDWR 2006).

3.7.4.1.33 Wright Fishhook Cactus. The Wright fishhook cactus occurs in portions of Emery, Sevier, and Wayne Counties, Utah (UDWR 2006). It is found growing on soils that range from clays to sandy silts to fine sands, typically on sites with well-developed biological soil crusts. This cactus grows in scattered pinyon-juniper and desert shrub plant communities at elevations ranging from 1,305 to 1,963 m (4,281 to 6,440 ft). The Wright fishhook cactus grows to heights of 6 to 12 cm (2 to 5 in.) and produces pink to white flowers in late April and May (BLM 2006f). Fruiting occurs in June and seed shed is in July.

Wright fishhook cactus was listed as endangered on October 11, 1979, and a recovery plan was published in 1985. The total population is estimated at fewer than 3,000 individuals on the basis of recent surveys (NatureServe 2011).

Potential threats to the Wright fishhook cactus include oil, coal, and gas exploration; OHV traffic; trampling of plants by livestock; road construction and maintenance; collection; and infestation by cactus-borer beetle larvae (CPC 2006h; NatureServe 2011).

The Wright fishhook cactus is known from Wayne County, southwestern Emery County, and southeastern Sevier County in Utah (UDWR 2006). The species occurs within the vicinity of the San Rafael and Tar Sand Triangle STSAs.

3.7.4.2 Species That Are Proposed for Listing under the Endangered Species Act

Species that are proposed for listing as threatened or endangered under the ESA are presented in this section. Their occurrence within oil shale basins and STSAs is presented in Table 3.7.4-3.

3.7.4.2.1 Graham's Beardtongue. The Graham's beardtongue is a perennial herbaceous plant that occurs in small populations along a narrow band (approximately 80 mi long by 5 mi wide) from Raven Ridge, west of Rangely, in Rio Blanco County, Colorado, westward to a point where Carbon, Duchesne, and Uintah Counties meet in Utah's Uinta Basin (USFWS 2006d). Typical habitat consists of exposed raw shale knolls and slopes derived from the Parachute Creek and Evacuation Creek Members of the Green River Formation. Most populations occur on the surface of the oil shale Mahogany ledge (71 FR 19158).

Graham's beardtongue has one to three stems that rise from a taproot and grow to a height of 7 to 18 cm (3 to 7 in.). Plants have leathery leaves and large, light- to deep-colored tubular lavender flowers that develop in late May and early June. The UDWR (2006) describes Graham's beardtongue sites occurring at elevations ranging from 1,430 to 2,600 m (4,692 to

8,530 ft) in pinyon-juniper and desert shrub plant communities. The Center for Native Ecosystems (2006b) reported in November 2003 that, of the 36 known sites of Graham's beardtongue, one-fourth were composed of fewer than 10 plants.

The USFWS published a proposed rule to determine whether Graham's beardtongue should be listed as threatened under the ESA (71 FR 3158) and to designate critical habitat for the species. The USFWS withdrew the proposed rule on December 19, 2006 (71 FR 76023), stating that listing is not warranted because threats to the species are not significant and are not likely to threaten or endanger the species in the foreseeable future. This decision, at least in part, was based on existing BLM policies, land use planning, and on-the-ground protective measures provided to the USFWS during the public comment period on the proposed rule. The proposed rule to list the Graham's beardtongue was reinstated based on court ruling.

Potential threats to this species include oil and gas exploration (both drilling and field development), tar sands and oil shale mining, OHV use, livestock and wildlife grazing, and overutilization for horticultural purposes. The Graham's beardtongue could occur in the Uinta Basin and in the Hill Creek, Pariette, P.R. Spring, and Raven Ridge, and Sunnyside STSAs.

3.7.4.3 Species That Are Candidates for Listing under the Endangered Species Act

Species that are candidates for listing as threatened or endangered under the ESA are presented in this section. Their occurrence within oil shale basins and STSAs is presented in Table 3.7.4-3.

3.7.4.3.1 Greater Sage-Grouse. The greater sage-grouse became a candidate for federal listing on March 23, 2010 (75 FR 13910). The listing of this species was determined to be warranted but was precluded by higher-priority listing actions. The USFWS assigned a listing priority number of 8 to this species because threats have a moderate to low magnitude, and are imminent.

The historic range of the greater sage-grouse included Washington, Oregon, California, Nevada, Idaho, Montana, Wyoming, Colorado, Utah, South Dakota, North Dakota, Kansas, Oklahoma, Nebraska, New Mexico, Arizona, and the Canadian provinces of British Columbia, Alberta, and Saskatchewan. 1,200,483 km^2 of potential sage-grouse habitat existed before 1800 (75 FR 13910). Greater sage-grouse currently occupy only about 56% (668,412 km^2) of the habitat that was available to them before the arrival of European settlers (BLM 2010b, 75 FR 13910) and have disappeared from Nebraska, Kansas, Oklahoma, New Mexico, Arizona, British Columbia, and Saskatchewan (USFWS 2010b). The total population size was estimated to be around 536,000 individuals in 2010 (NatureServe 2011).

The greater sage-grouse is a colonial breeder that mates in April (UDWR 2011a). Migration distances of up to 161 km have been recorded, but birds in some locations do not migrate at all (75 FR 13910). It requires various species of sagebrush throughout its lifecycle for nesting, food, and shelter (75 FR 13910). It can be found in sagebrush plains, foothills, and mountain valleys (UDWR 2011a). Young birds will eat grasshoppers, beetles, and ants, but adult greater sage-grouse will mainly consume sagebrush (BLM 2011b).

The main threats to greater sage-grouse are predation, wildfires, invasive weeds, agriculture, urban expansion, and energy development (BLM 2011b). Oil shale and tar sands are predicted for increased development in the sage-grouse range and this development would involve removal of habitat and could contribute to future population declines (75 FR 13910). The species could occur within or in the vicinity of development areas located in the Green River, Piceance, Uinta, and Washakie Basins and the Argyle Canyon, Asphalt Ridge, Hill Creek, Pariette, P.R. Spring, Raven Ridge, and Sunnyside STSAs.

The BLM recognizes the challenge of authorizing various human land uses (including energy development) on public lands and protecting the greater sage-grouse. The BLM has participated in the organization of conservation committees and developed Instructional Memoranda (IM) and other reports to outline the necessary steps that could be necessary for energy development that would also work towards conservation goals. These IMs and other sage-grouse policy information are provided in Appendix K. Local sage grouse working groups have been formed across the region to support activities that improve sage grouse habitat. Executive Order (E.O.) 2011-5 for the State of Wyoming (Wyoming Governor's Office 2011) outlined the identification and protection of "core population areas" for the greater sage-grouse within the State of Wyoming. See Appendix K for additional information on Wyoming E.O. 2011-5. Similarly, Colorado Parks and Wildlife (CPW) identified Preliminary Priority Habitat (PPH) for the greater sage-grouse. The State of Utah maintains a database of occupied habitat areas for the greater sage-grouse. These occupied habitat areas were determined by UDWR field biologists in 2010. BLM is currently working with the CPW and UDWR to refine the delineation of priority habitats in these states. As discussed in Section 2.3.3.1, it is important to note that unlike the states of Colorado and Wyoming, the State of Utah has not yet completed the process of identifying core or priority greater sage-grouse habitat. The best available data to represent greater sage-grouse habitat in Utah is the UDWR occupied habitat. Greater sage-grouse core or priority areas considered for this PEIS are summarized in the following text box.

3.7.4.3.2 Gunnison Sage-Grouse. The Gunnison sage-grouse became a candidate for federal listing on September 28, 2010 (75 FR 59804). The listing of this species was determined to be warranted but was precluded by higher-priority listing actions. The USFWS assigned a listing priority number of 2 to this species because threats have a high magnitude, and are imminent.

Gunnison sage-grouse historically occupied 21,370 mi^2 throughout southwestern Colorado, northwestern New Mexico, northeastern Arizona, and southeastern Utah (71 FR 19954). Currently, only seven widely scattered and isolated populations occur in Colorado and Utah, occupying 1,511 mi^2 in Gunnison Basin, San Miguel Basin, Monticello–Dove Creek, Pĩnon Mesa, Crawford, Cerro Summit–Cimarron–Sims Mesa, and Poncha Pass (75 FR 59804). Gunnison sage-grouse now occupy about 10% of the habitat that existed before the arrival of European settlers (BLM 2010b). The breeding population size was estimated to be fewer than 4,000 individuals in 2000 with the largest population (2,000–3,000) occurring primarily in Gunnison and Saguache Counties, Colorado. The remaining six populations have fewer than 300 breeding individuals (NatureServe 2011).

The Gunnison sage-grouse is a colonial breeder that mates in the spring (UDWR 2011a). It relies heavily on sagebrush for shelter and food throughout the year. Forbs and insects are eaten during the summer and early fall, but its diet consists entirely of sagebrush during the winter (71 FR 19954).

The main threat to the Gunnison sage-grouse, in addition to predation, is the fragmentation and degradation of sagebrush habitats due to conversion to cropland, energy development, and urban development (NatureServe 2011). All Gunnison sage-grouse habitat was classified by the BLM as areas for gas and oil potential (75 FR 59804). The species could occur within or in the vicinity of development areas located in the P.R. Spring and White Canyon STSAs. Other threats include fencing (increases mortality due to collision and increased perch sites for nest predators), fires (increases weeds and degrades suitable habitat), and domestic grazing (changes plant communities and soils) (75 FR 59804).

Greater Sage-Grouse Core/Priority Habitat Data Sources and Definitions

1. **Colorado** – Preliminary Priority Habitat (PPH); areas of high probability of greater sage-grouse use (summer, winter, brooding) within a 4 mi (6.5 km) buffer around leks that have been active within the past 10 years. Source: CPW (2012).
2. **Utah** – Greater sage-grouse occupied habitat areas in Utah as determined by UDWR field biologists in 2011. Source: UDWR (2012).
3. **Wyoming** – Greater sage-grouse core areas defined by the Governor’s Implementation Team. Version 3 core areas were approved by the governor of Wyoming on June 29, 2010. Source: WGFD (2010c).

3.7.4.3.3 Gunnison’s Prairie Dog. The Gunnison’s prairie dog is a candidate for listing in that portion of its range in central and south-central Colorado and north-central New Mexico. The USFWS recently published a 12-month finding for the Gunnison’s prairie dog in which it determined that the species is not threatened or endangered throughout all of its range, but that the portion of the current range of the species located in central and south-central Colorado and north-central New Mexico represents a significant portion of the range where the Gunnison’s prairie dog is warranted for listing under the ESA (USFWS 2008). Although listing was precluded by higher priority actions, the USFWS assigned a listing priority number of 2 to this species because threats have a high magnitude, and are imminent.

The Gunnison’s prairie dog is a colonial species in the family Sciuridae and historically occurred in large colonies over large areas (USFWS 2008). Gunnison’s prairie dog habitat includes level to gently sloping grasslands and semidesert and montane shrublands, at elevations from 6,000 to 12,000 ft (1,830 to 3,660 m). Foods include grasses, forbs, sedges, and shrubs.

The current distribution of the species includes northeastern Arizona; central, south-central, and southwestern Colorado; north-central and northwestern New Mexico; and extreme southeastern Utah (USFWS 2008). Between 1916 and the present, habitat occupied by Gunnison’s prairie dogs throughout its range declined from approximately 24,000,000 acres (9,700,000 ha) to between 340,000 and 500,000 acres (136,000 and 200,000 ha). This represents a rangewide decline of greater than 95% (USFWS 2008). Gunnison’s prairie dogs occur in two separate range areas—higher elevations in the northeastern part of the range (montane areas) and lower elevations elsewhere (prairie areas).

Gunnison's prairie dogs are affected by a variety of anthropogenic and ecological factors. In evaluating these factors, the USFWS determined that the destruction and modification of Gunnison's prairie dog's habitat or range currently are not significant threats. Agriculture, urbanization, roads, and oil and gas development each currently affect a small percentage of Gunnison's prairie dog habitat. Effects of livestock grazing, while widespread, have not resulted in measurable population declines.

Plague has a significant effect on Gunnison's prairie dog populations (USFWS 2008). Periodic epizootic plague events generally kill more than 99% of an affected population. Whether populations recover from these events depends on the availability of other populations to recolonize affected areas and the frequency of outbreaks. Populations in the more mesic montane areas of the species' range appear to have been widely and severely affected by plague (USFWS 2008). Large populations have been repeatedly affected by plague and have shown no substantial recovery over long periods of time. This has left smaller, more scattered populations throughout the montane range portion. Evidence shows that many of the prairie populations recover more rapidly from plague epizootics, probably because of the availability of nearby colonizers.

On the basis of the map presented in USFWS (2008), the Gunnison's prairie dog range is outside of the areas being considered for leasing for commercial oil shale and tar sands development.

3.7.4.3.4 Western Yellow-Billed Cuckoo. The western yellow-billed cuckoo became a candidate for federal listing on July 25, 2001 (USFWS 2001). The listing of this species as endangered was determined to be warranted but was precluded by higher-priority listing actions. The yellow-billed cuckoo was historically widespread and locally common in portions of its range, but was generally uncommon to rare in the study area (USFWS 2000a, 2001).

The western yellow-billed cuckoo is a neotropical migrant bird. It depends on large blocks of intact riparian habitat for nesting, especially woodlands of cottonwoods and willows, with a dense understory of shrubs (USFWS 2001). It is mostly insectivorous, with cicadas, katydids, and caterpillars forming the bulk of its diet.

The western yellow-billed cuckoo has faced significant population declines because of loss or degradation of riparian habitat, increased use of pesticides, reduced food supply, and low colonization rates (Hughes 1999; USFWS 2001). Habitat degradation and loss have been attributed to conversion to agriculture, grazing, dams and river regulation, bank protection and channelization for flood control, and invasion by exotic plants such as tamarisk. Additional impacts identified in the study area include recreation and oil and gas drilling (Howe and Hanberg 2000).

Suitable yellow-billed cuckoo habitat (cottonwood forest) occurs along the major rivers of the area, including the Colorado, Green, and White Rivers. The USFWS considers this species to be present only within portions of the study area within Utah (Appendix F). On this basis, the species could occur within or in the vicinity of development areas located in the Uinta Basin and the Asphalt Ridge STSA.

3.7.4.3.5 White River Beardtongue. The White River beardtongue is a perennial herbaceous plant that occurs in the Green River Formation in the Uinta Basin of northeastern Utah and Colorado. Existing populations occur in Duchesne and Uintah Counties in Utah and in Rio Blanco County, Colorado (UDWR 2006). It is found on semibarren areas on soils that are dry, shallow, and fine textured with fragmented shale. It can be found at elevations ranging from 1,500 to 2,040 m (4,921 to 6,693 ft) on dry substrates near the bottom of the Uinta Basin to upper slopes and ridge crests. White River beardtongue typically grows in pinyon-juniper, desert shrub, and mixed desert shrub communities, and flowers in late May and early June (USFWS 2006g).

The species range is composed of small scattered populations extending from Raven Ridge near the White River in Rio Blanco County, Colorado, westward into southern Uintah County, Utah, in the area of Evacuation Creek over a distance of about 30 km (20 mi) (USFWS 2006g). Of the estimated population of 22,780 individual plants in Utah in 1995, about 16,600 occurred on BLM-administered land within the Vernal Field Office (USFWS 2006g). As of 1998, only two populations totaling about 50 plants were known from Colorado in the vicinity of Raven Ridge.

Potential threats to the species include ground-disturbing activities such as oil and gas development, oil shale mining, OHV use, and impacts from livestock grazing. Several interstate gas and oil pipelines exist in the vicinity of known populations (USFWS 2006g). With such a small range and the fragmented population structure over the 20-mi range of the species, any habitat destruction poses a threat to the White River beardtongue.

The White River beardtongue could occur in or in the vicinity of development areas within the Green River Formation in the Uinta Basin. This includes the following development areas: Uinta Basin and the Hill Creek, P.R. Spring, and Raven Ridge STSAs.

3.7.4.4 BLM-Designated Sensitive Species and State-Listed Species

The BLM and the states of Colorado, Utah, and Wyoming maintain lists of sensitive plant and animal species. Many of these species have restricted distributions within the states, limited population sizes, and specialized habitat requirements that make them particularly vulnerable to human or natural perturbations. Special status provides a measure of protection through consideration in planning processes and is intended, at least in part, to avoid the need for federal listing under the ESA. The BLM manages BLM-listed sensitive species and state-listed species as if they were candidates for federal listing under the ESA. The species and their habitats that could occur in potential development areas are presented in Table E-1 of Appendix E.

There are 110 BLM-listed sensitive species that occur in counties of potential development areas. Of these, 55 potentially occur in the Green River, 38 in the Washakie, 46 in the Piceance, and 42 in the Uinta Basins; 58 potentially occur in STSAs (Table 3.7.4-2). Of these BLM-listed species, 49 are plants, 5 are invertebrates, 6 are fish, 6 are amphibians, 6 are reptiles, 22 are birds, and 16 are mammals (Table 3.7.4-1).

3.7.4.5 Other Species of Concern

In addition to the species discussed in Section 3.7.4.1, there are two species that potentially occur in oil shale and tar sands areas and for which the USFWS has developed conservation measures. These species are the bald eagle and the Colorado River cutthroat trout. These species have either been recently removed from the list of threatened and endangered species list (bald eagle) or have recently undergone a formal status review by the USFWS, but listing was determined to be not warranted at this time (Colorado River cutthroat trout). The Colorado River cutthroat trout (a BLM-sensitive species) is discussed in Sections 3.7.1 and 3.7.2, and the bald eagle is discussed in this section.

The southern bald eagle was federally listed as endangered on March 11, 1967 (USFWS 1967). In 1978, bald eagle populations in all but five of the coterminous United States were listed as endangered; in the remaining five states, bald eagles were listed as threatened. The listing status throughout the conterminous United States was changed to threatened on July 12, 1995, and the bald eagle was proposed for delisting on July 6, 1999 (USFWS 1999). The bald eagle was removed from the list of endangered and threatened wildlife on August 8, 2007 (USFWS 2007c). The bald eagle continues to be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. The current U.S. range of the bald eagle includes all of the 48 conterminous states, plus Alaska and the District of Columbia.

Bald eagles typically nest in areas free of human disturbance, especially in large trees near water and occasionally on cliffs. The nesting season is about 6 months long. Most bald eagles migrate long distances to wintering areas. Wintering sites, which may attract large numbers of bald eagles, are generally near open water and include large trees for perching and night roosting. In potential development areas, bald eagles are most commonly seen along the major rivers such as the Colorado, Green, and White Rivers; they could occur in all of the oil shale basins and STSAs. Fish are the primary food source, although waterfowl, other birds, prairie dogs, and carrion are also eaten.

The take or disturbance of bald eagles is prohibited under the Bald and Golden Eagle Protection Act. Under 50 CFR 22.26 and 2.27; activities that take eagles or eagle nests may violate the Bald and Golden Eagle Protection Act. The Bald and Golden Eagle Protection Act defines the "take" of an eagle to include a broad range of actions, including to "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, or molest or disturb." In 2009, the USFWS issued regulations (50 CFR 22.3) that define "disturb" as, "to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior."

3.8 VISUAL RESOURCES

3.8.1 Introduction

Visual resources refer to all objects (man-made and natural, moving and stationary) and features (e.g., landforms and water bodies) that are visible on a landscape. These resources add to or detract from the scenic quality of the landscape, that is, the visual appeal of the landscape.[17]

The BLM's responsibility for managing visual (scenic) resources of public lands is established by law. FLPMA states that "public lands will be managed in a manner which will protect the quality of scenic values of these lands."

The BLM conducts visual inventories and analyses within the guidelines established in its Visual Resource Management (VRM) System (BLM 1984a; 1986a,b). The BLM uses the VRM procedures and methods to support decision making for planning activities and reviews of proposed developments on BLM-administered lands.

The VRM system consists of three phases: (1) inventory of scenic values and assignment of visual resource inventory (VRI) classes; (2) designation of BLM management classes for all public lands using the RMP process; and (3) use of the Visual Contrast Rating System (VCRS) to evaluate the compatibility of a proposed project with the existing VRM Class for the proposed project location, and to determine the nature and extent of visual impacts associated with the project. If the project is subsequently implemented, design considerations and impact mitigation measures may be used to minimize the visual impacts of the project.

A visual resource classification is based on the intrinsic scenic quality of a view, the level of public concern (sensitivity) to changes in that view, and the distance between viewers and the view. The final result of the VRM process is the assignment of a VRM Class that provides the basis for the consideration of visual resources in the BLM's resource management planning process. The text box that follows describes the BLM's VRM system for inventorying scenic values and assigning management classes. Designation of VRM classes is done through the RMP process and takes into account both the scenic qualities and potential uses of an area. Changes to VRM classes are also accomplished through the RMP process and may result from changes in scenic values over time, or as a result of land use decisions.

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[17] A visual impact is the creation of an intrusion or perceptible contrast that affects the scenic quality of a landscape. A visual impact can be perceived by an individual or group as either positive or negative, depending on a variety of factors or conditions (e.g., personal experience, time of day, and weather/seasonal conditions).

When a project is proposed, potential visual impacts are evaluated relative to an RMP's visual management objectives for the affected area with the use of the VCRS. The VCRS is a systematic process to analyze potential visual impacts of proposed projects and activities (BLM 1986b). Contrast rating assesses the visual contrast between a project and the existing landscape. Contrast is assessed by comparing project features (explained in a detailed project description) with the major features of the existing landscape (contained in the VRM classes/objectives) in terms of the basic design elements of form, line, color, and texture. Comparisons are made on the basis of views from key observation points, critical viewpoints, typical views of representative landscapes, and views of special features. Combining the assessment of a proposed project's impact on an area's visual resources with the VRM objectives from the RMP may result in project modifications and/or the development of mitigation measures. Visual contrasts inconsistent with the VRM class objectives for the affected area are prohibited.

3.8.2 Oil Shale Areas

3.8.2.1 Piceance Basin

The oil shale area in Colorado, commonly referred to as the Piceance Basin, is largely contained within the Roan Plateau (see Figure 1.2-1). The Roan Plateau is composed of two major landform types: the extensive, deeply dissected, cliff-bench complexes and steep cliff formations of the Roan and Book Cliffs on the southern end of the plateau, and the grass-, shrub-, and woodland-covered benches and mesas of the Piceance Creek watershed to the north (Chapman et al. 2006) (Figure 3.8.2-1). Elevations range from approximately 5,200 ft above mean sea level (MSL) along the Colorado River to nearly 9,300 ft above MSL atop the plateau. The top of the plateau slopes generally northward and is dissected by tributaries of Parachute Creek and Piceance Creek. The eastern, southern, and western edges of the plateau are defined by steep slopes and prominent cliffs, known as the Roan Cliffs; the Book Cliffs extend farther westward along the south face of the Plateau into Utah (BLM 2004c).

The Roan and Book Cliffs are major scarp slopes that rise dramatically (3,000 to 4,000 ft) from the Colorado River valley to the forested plateau rim. Vegetation found on the escarpments and benches includes Douglas fir forest at higher elevations, to grassland or shrubland on lower, drier sites. Pinyon-juniper woodland often dominates escarpments and benches that are covered by shallow soils (Chapman et al. 2006).

The Roan and Book Cliffs are highly sensitive visual resources. The Roan Cliffs are visible from the communities of Parachute, Battlement Mesa, Rifle, Silt, and New Castle and to travelers on I-70 and State Highway 13. The massive forms of the steep cliffs dominate views from the valley floor and the I-70 corridor, providing dramatic color contrasts to the heavily vegetated upper slopes. Human-caused visual impacts are minimal, but some road cuts are visible on the face of the Roan Cliffs. Public sensitivity to alterations in these landscapes is high (BLM 1983b, 2004c), and most of the area is managed as VRM Class II. The faces of the Book

BLM VRM System: Inventory of Scenic Values and Assignment of Management Classes

Scenic Quality Evaluation. BLM inventory guidelines rate the apparent scenic quality of discrete areas of land as A, B, or C on the basis of their landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications (BLM 1986a). A-rated areas have outstanding or distinctive diversity or interest, B-rated areas have common or average diversity or interest, and C-rated areas have minimal diversity or interest.

Sensitivity Level Analysis. Sensitivity levels measure public concern for scenic quality. Areas are assigned a high, medium, or low sensitivity level by analyzing indicators of public concern: types of users, amount of use, public interest, adjacent land uses, special areas, and other factors that may be indicators of visual sensitivity. Special areas such as Wilderness Study Areas, Wild and Scenic Rivers, and Scenic Roads or Trails require special consideration for protection of their scenic quality.

Distance Zone Delineation. The visual impact of a particular project will become less perceptible with increasing distance between the viewer and the project. The BLM VRM system uses three distance zones to account for this effect. It looks at likely viewing locations such as nearby highways, rivers, scenic overlooks, or other locations from which most viewers would observe a particular site. The foreground-middleground zone includes areas at a distance of less than 3 to 5 mi from the viewer. Areas viewed beyond the foreground-middleground zone but usually less than 15 mi from the viewer are in the background zone. Areas hidden from view in the foreground-middleground zone or background zone are in the seldom-seen zone.

Visual Resource Inventory Classification. Through an overlay analysis, areas are assigned to one of four visual resource inventory classes based on the scenic quality, visual sensitivity, and distance zones. Inventory classes are informational in nature and provide the basis for considering visual values in the RMP process.

Visual Resource Management Classification. Visual resource management classes are assigned through the RMP process by considering the visual resource inventory and management goals for the area. Areas are assigned to one of four management classes; the management objectives are as follows:

- Class I Objective: Preserve the existing character of the landscape. The level of change should be very low and must not attract attention.
- Class II Objective: Retain the existing character of the landscape. Allow a low level of change that should not attract the attention of a casual observer.
- Class III Objective: Partially retain the existing character of the landscape. Allow a moderate level of change that may attract attention without dominating the view of a casual observer.
- Class IV Objective: Provide for management activities that require major modifications of the existing character of the landscape. The level of change may be high and may dominate the view and be the major focus of viewer attention.

Cliffs, the Roan Creek Area, and the I-70 corridor have also been identified as high-value scenic areas (BLM 1985c), as have NOSR 1 and 3 and the East Fork Parachute Creek Canyon, a regionally significant visual resource (BLM 2004c). Some segments of tributaries of Parachute Creek are eligible for WSR status because of their outstandingly remarkable scenic value (BLM 1994b). The Dinosaur Diamond National Scenic Byway (also known as the Dinosaur Diamond Prehistoric Highway) passes within approximately 7 mi of the western boundary of the oil shale area.

FIGURE 3.8.2-1 Landscape in the Piceance Basin

The northern portion of the plateau is characterized by broad, grass-, shrub-, and woodland-covered benches and mesas, with areas of high relief alternating with areas of low relief. On floodplains and terraces, some irrigated cropland occurs. Oil and natural gas wells are also present (Chapman et al. 2006). Scenic values are lower than for the Roan and Book Cliffs areas on the southern edge of the Roan Plateau. Many of the public lands in the area are managed as VRM Class III (BLM 1994b).

3.8.2.2 Uinta Basin

The oil shale area within the Uinta Basin is located in the Uinta Basin Floor ecoregion, an arid, saucer-shaped synclinal basin. The area contains mountain-fed streams, alluvial terraces, outwash terraces, floodplains, hills, and ridges. Mesas and benches alternate with lower, more arable land (Chapman et al. 2006). The area is dissected by several rivers, including the Green River, the White River, and their tributaries. Vegetation consists primarily of desert shrubs and grasses, but cottonwood and introduced Russian olive trees may be found in riparian areas.

Visual impacts from existing human activities in the area are abundant. They include impacts associated with intensive energy development in the area's major oil and gas fields, mining, irrigated agriculture, and grazing. Impacts associated with energy development include oil and gas wells, pipelines, pump and meter stations, roads (mostly unpaved), landing strips, and transmission lines. Streams are often diverted for irrigation, both for crops (such as alfalfa, small grain, and corn) on arable, gently sloping terraces and valley floors, and for pasture on stonier soils. Nonirrigated areas are used for livestock grazing (Chapman et al. 2006). OHV use has also resulted in significant visual impacts north of the White River (BLM 2005f) (Figure 3.8.2-2).

Within the Uinta Basin oil shale area, the highest scenic quality is found in the Bitter Creek Drainage and along portions of the White and Green River corridors (BLM 2002d). The Winter Ridge WSA, at the southern end of the oil shale area, is currently managed as VRM Class I. Areas managed as VRM Class II are Nine Mile Canyon (at the far western edge of the oil shale area), the White River Corridor, and the Upper Green River. The proximity of intense exploration and development near areas of high scenic quality and the increasing number of people seeking recreation are creating resource use conflicts, particularly in the White River corridor (BLM 2005f). The remainder of the oil shale area is managed as either VRM Class III or VRM Class IV. Under the Approved Vernal RMP, two segments of the Green River totaling approximately 52 mi were found to be suitable for inclusion into the National Wild and Scenic River System, with a tentative classification of "Scenic" for both river segments. The Upper Green River segment (22 mi) extends from Little Hole to the Utah state line. The Lower Green River segment (30 mi) extends from the public land boundary south of Ouray to the Carbon County line (BLM 2008d). The Dinosaur Diamond National Scenic Byway passes within approximately 5 mi of the northeastern boundary of the oil shale area.

3.8.2.3 Green River Basin

The Green River Basin oil shale area includes the Green River Basin and lands to the east of it, including the Jack Morrow Hills, and it extends about 30 mi east of the eastern edge of the

FIGURE 3.8.2-2 Landscape in the Uinta Basin

Jack Morrow Hills. Except for the extreme southern portion of the oil shale area (south of the Green River Basin), the area consists primarily of rolling sagebrush steppe, hills and low mountains, dunes, and playas, with shrub and grass vegetation. The landscape is varied and characterized by highly erodible soils and multicolored, horizontally layered sedimentary bedrock. Colorful badlands landscapes are common. Riparian vegetation is found along perennial streams, intermittent surface water locations, and rivers; sparser vegetation is located on side slopes and hillsides; and alkaline vegetation is found in some areas (BLM 2004e).

At the edges of the basin, elevations are higher, and some pinyon-juniper is found. The far southern portion of the oil shale area includes the northern slopes of the Uinta Mountains, characterized by mountain slopes with steep canyons, ponderosa and lodgepole pine, Douglas fir, and aspen woodlands. The Green River, its tributaries, and other permanent and intermittent streams drain the basin, generally southward (Chapman et al. 2006). Flaming Gorge Reservoir is a large water body in an area of deep canyons.

Although much of the Green River Basin oil shale area is relatively flat, featureless plains or rolling hills, there are several areas of high visual sensitivity. The Green River has been identified as an important scenic resource (BLM 2003). Many National Historic and Scenic Trails pass through the Green River Basin, including the Oregon Trail (and several cutoffs), the Overland Trail, the Mormon Pioneer Trail, the Northern and Southern Cherokee Trails, the Pony Express Trail, and the California Trail. The Devil's Playground/Twin Butte WSA is located within the southern portion of the Green River Basin oil shale area. ACECs within or partially within the Green River Basin oil shale area include the Currant Creek portion and Sage Creek portion of the Red Creek Badlands ACEC, Special Status Plant Species ACEC, and the Pine Springs ACEC. The Flaming Gorge Uintas National Scenic Byway passes within approximately 6 mi of the southern boundary of the oil shale area.

East of the Green River Basin, the Jack Morrow Hills area contains a variety of unusual landforms and several historical sites and roads, as well as landscapes of significance to Native Americans (BLM 2004d). The oil shale area includes portions of the Greater Sand Dunes ACEC and the Buffalo Hump WSA.

Cultural modifications within the basin include oil and gas production (such as well facilities, pipelines, roads, and power distribution lines), mining (including soda ash and coal), and livestock grazing operations and associated structures (such as fences and water developments) (BLM 2004e), as well as a number of small towns.

3.8.2.4 Washakie Basin

The Washakie Basin is an area of rolling sagebrush steppe, essentially a plain with hills, dunes, and playas, and with shrub and grass vegetation (BLM 2004e; Chapman et al. 2006). At the edges of the basin, elevations are higher, and some pinyon-juniper is found. A few streams, mostly intermittent, drain the basin.

The Washakie Basin is an area of active energy development, including oil and gas, coalbed methane, and other products. Visual disturbances associated with these types of activities, including roads, wells, pipelines, compressor stations, and meter stations, are found in the basin.

Just north of the oil shale area, the historic Overland Trail runs generally east–west through the northern portion of the Washakie Basin, and a BLM backcountry byway, Ft. Lacede Loop, is located in the northern portion of the basin. The Southern Route of the Cherokee Trail passes east to west through the basin, near the Colorado state line.

3.8.3 Special Tar Sand Areas

3.8.3.1 Argyle Canyon STSA

The Argyle Canyon STSA has a variety of landforms, including ridges, benches, and steep canyons. The area is dissected by numerous intermittent streams and a few perennial streams, and it has rugged, high-relief terrain, with local relief ranging from about 660 to 1,300 ft (USGS 1980b).

Scenic quality in the Argyle Canyon STSA varies, but is generally high, because of the variety of both landform and vegetation, which ranges from Douglas fir and aspen at higher elevations to big sagebrush–grass communities and riparian areas along Argyle Creek (BLM 1984b). Most of the STSA is managed as VRM Class III.

Argyle Canyon is an area of the STSA of particular concern for visual values. Argyle Creek was under consideration as eligible for WSR status because of its outstandingly remarkable scenic value (BLM 2005c); however, it was determined not to be suitable under the relevant test and was not classified as a WSR in the 2008 Vernal RMP. Much of the BLM portion of the STSA is bordered by a USFS roadless area to the north that includes small portions of the STSA. The Dinosaur Diamond National Scenic Byway passes through the eastern portion of the Argyle Canyon STSA. The Energy Loop: Huntington/Eccles Canyons National Scenic Byway passes within approximately 7 mi of the western boundary of the STSA.

3.8.3.2 Asphalt Ridge STSA

The three areas that compose the Asphalt Ridge STSA vary in scenic quality. The largest area closest to Vernal (Asphalt Ridge) is a cuesta or asymmetrical ridge, with mostly gently sloping topography. Vegetation consists primarily of pinyon-juniper and mixed shrubs.

The Asphalt Ridge portion of the STSA is generally of low scenic quality (BLM 1984b). It is in close proximity to the towns of Maeser, Vernal, and Naples, with urbanized areas that contain numerous visual intrusions visible from portions of the ridge. Cultural modifications that have existing visual impacts in the STSA include roads (e.g., State Highway 40), power lines, and industrial facilities. Some crops and pastureland are found in the far eastern portions of the STSA. The Asphalt Ridge portion of the STSA is designated as VRM Class IV in the Approved Vernal RMP (BLM 2008d). The Dinosaur Diamond National Scenic Byway (State Highway 40) passes through the Asphalt Ridge portion of the STSA.

The two western portions of the STSA (north-northeast of Whiterocks) are areas of generally higher scenic quality than the Asphalt Ridge portion (BLM 1984b). These portions compose a dissected plain. The part closest to the Asphalt Ridge portion (primarily on the Uintah and Ouray Reservation) was designated as VRM Class IV in the Approved Vernal RMP (BLM 2008d). The westernmost portion of the STSA (on the Ashley National Forest) is an area of high scenic quality and sensitivity, with stone outcrops and riparian views along the White Rocks River, which provide pleasing visual contrasts with the predominant gray-green pinyon-juniper and shrub vegetation (BLM 1984b). Both areas abut USFS roadless areas on their northern and/or eastern boundaries.

3.8.3.3 Hill Creek STSA

The Hill Creek STSA is a well dissected, deeply incised, rugged upland. The entire area is a north-sloping cuesta in which the plateau surface slopes toward the north. The landform is generally rolling desert topography with deeply incised canyons and rocky buttes. Vegetation is generally sparse at lower elevations and more dense at higher elevations. Two north-flowing perennial streams drain the central and eastern portions of the STSA (USGS 1980c).

The scenic quality in the Hill Creek STSA is moderate; the STSA is managed as VRM Class III and Class IV. The STSA is visible from Big Pack Mountain to the north (BLM 1984b), and the Winter Ridge WSA (managed as VRM Class I) is less than 0.5 km (0.3 mi) from the eastern border of the Hill Creek STSA. Cultural modifications include roads, trails, and landing strips.

3.8.3.4 Pariette STSA

The Pariette STSA is a gently sloping dissected plain that includes low mesas and buttes, ranging up to about 300 ft maximum local relief, with relief generally less than 100 ft. The area is drained predominantly eastward by Pariette Draw and Castle Peak Draw.

Scenic quality in the Pariette STSA is low; the landscape is visually homogenous, with cold desert shrubs and flat to rolling landform with occasional low hills and ridges, which are common in the region (BLM 1984b). Cultural modifications with existing visual impacts in the STSA include roads and trails, a pipeline and meter station, and some croplands along the northern border of the STSA. Gas processing plants are located along the southern border of the STSA, with an electrical substation nearby. The Pariette STSA is designated as VRM Class IV in the Approved Vernal RMP (BLM 2008d). The Pariette Wetlands ACEC overlaps portions of the STSA. The Dinosaur Diamond National Scenic Byway passes within approximately 2 mi northwest of the extreme western boundary of the STSA.

3.8.3.5 P.R. Spring STSA

The P.R. Spring STSA is located on the East Tavaputs Plateau to the immediate east of the Hill Creek STSA. The southern edge of the P.R. Spring STSA borders the Book Cliffs–Roan Plateau divide. Like the Hill Creek STSA, the plateau surface slopes northward. The area is drained by perennial streams that run generally north and northwest (USGS 1980d). The terrain consists of long ridges running generally northwest to southeast, separated by canyons 820 to 1,475 ft deep. Vegetation consists primarily of mountain shrub and pinyon-juniper, with stands of Douglas fir and other conifers on east- and north-facing slopes (BLM 1984b).

The scenic quality of the STSA is generally low; most of it is managed as VRM Class IV. High-quality panoramic views of the Book Cliffs and other distant landforms, however, are available from the top of the Roan Cliffs along the southeastern boundary of the STSA (BLM 1984b). Cultural modifications include oil and gas development and associated structures, roads, trails, and landing strips. Much of the Winter Ridge WSA (managed as VRM Class I) is located within the western portion of the P.R. Spring STSA, and the far southern part of the STSA overlaps a small portion of the Flume Canyon WSA.

3.8.3.6 Raven Ridge STSA

The Raven Ridge STSA consists primarily of two parallel hogback ridges (Raven Ridge and Squaw Ridge) running northwest to southeast. The ridge extends beyond the Colorado state line to the southeast. The southwestern portion of the STSA is a slightly dissected plain. The ridge is drained by intermittent washes (USGS 1980a).

The scenic quality for this STSA is generally low; vegetation is cold desert shrubs, and the landform (rolling hills with sparse vegetation, except for the ridge itself) is relatively common in the region. Cultural modifications with existing visual impacts in the STSA include roads and trails, power lines, pipelines, and a natural gas facility. The Raven Ridge STSA is designated as VRM Class IV in the Approved Vernal RMP (BLM 2008d). Portions of the STSA are visible from Dinosaur National Monument (BLM 1984b), the closest portion of which is located approximately 7 mi north of the northernmost portion of the STSA. The Dinosaur Diamond National Scenic Byway passes within approximately 1/8 mi of the northeastern boundary of the STSA. Raven Ridge is an area of high OHV use, with resultant visual impacts (BLM 2005e).

3.8.3.7 San Rafael Swell STSA

The San Rafael Swell STSA is located within the San Rafael Swell, a northeast-to-southwest trending dome approximately 70 mi long by 50 mi wide. An open, gently domed area (Sinbad Country) about 40 mi long and 10 mi wide occupies the central part of the swell and contains most of the STSA. Sinbad Country is bordered on the east and southeast by the spectacular sandstone hogbacks of the San Rafael Reef. I-70 passes through the middle of the swell and the STSA. The southwest and west sides of Sinbad Country are well dissected, and they feature many "castles," irregular mesas, and benches, as much as 700 ft above the general level of the swell. The land surface south of I-70 is not deeply dissected and is primarily gently rolling plain with isolated buttes and knolls. North of I-70, the relief is greater, with deeply dissected canyons and escarpments carved by the San Rafael River and its tributaries. Relief is greatest near the San Rafael River, where it is up to 1,700 ft (USGS 1980e).

The vegetation of the San Rafael Swell includes pinyon-juniper and Douglas fir near water sources. Cottonwood trees are found in areas along the perennial streams. Greasewood, sagebrush, and rabbitbrush are found along washes, and sparse grass and prickly pear are common (Williams 2002).

The San Rafael Swell area offers outstanding scenic quality and is one of the region's most well-known and popular scenic attractions. Within the San Rafael Swell, features such as the Wedge Overlook (Figure 3.8.3-1), San Rafael Reef, Mexican Mountain, Temple Mountain, and Buckhorn Draw attract high levels of recreation visitation, as does the I-70 corridor. The I-70 Scenic Corridor ACEC is managed to maintain the scenic qualities of the San Rafael Swell, where the interstate bisects the area. Old uranium mines, dirt roads, livestock improvements, and simple recreation facilities are evident in some locations, as are petroglyphs, pictographs, and some historic structures (BLM 2001b). Other scenic attractions include riparian areas along the San Rafael River and Muddy Creek. The Dinosaur Diamond National Scenic Byway passes within approximately 6.5 mi of the northeastern boundary of the STSA.

FIGURE 3.8.3-1 View from Wedge Overlook, San Rafael Swell near Castledale, Utah

The STSA overlaps several ACECs, including four (the I-70 Scenic Corridor ACEC, San Rafael Canyon ACEC, San Rafael Reef ACEC, and Sid's Mountain ACEC) designated for scenic value. Significant portions of some STSA parcels not only cross the I-70 Scenic Corridor ACEC but overlap or are immediately adjacent to six WSAs, which are primarily designated as VRI Class II but are managed as VRM Class I in accordance with the 1991 San Rafael RMP. Major portions of the STSA are visible from the I-70 Scenic Corridor (BLM 1984b). Portions of STSA parcels outside the WSAs are mostly designated VRI Class III and IV and are managed as VRM Class III and IV, with some smaller VRI and VRM Class II areas. The Muddy Creek and Segers Hole ACECs are located approximately 2 and 10 mi south of the southwestern boundary of the STSA, respectively; both ACECs contain outstandingly remarkable scenic values.

3.8.3.8 Sunnyside STSA

The Sunnyside STSA is characterized by numerous rugged, mountainous forested areas and canyons, perennial streams, and mountaintop vistas. Bands of red rock cliffs are ubiquitous throughout and extend along most of the ridges. Many ridges extend downward off the plateaus, creating a sequence and layering of ridges that add much visual variety and spatial definition to the study area. Cliffs are often broken up and of varying heights. Vegetation consists of pinyon-juniper clumps, junipers, and firs, intermixed with sagebrush and grasses on the upper ridges and plateaus; sagebrush, rabbitbrush, greasewood, and grasses with groupings of aspens, cottonwoods, willows, tamarisks, and associated riparian species dominate the canyon floors (BLM 2004f).

The STSA and surrounding areas have very high scenic quality and have been described as offering "outstanding visual values" (BLM 1984b). The STSA lands are managed as VRM Class II and Class III, reflecting the high scenic values and sensitivity of the landscape to modification; portions of the STSA are visible from U.S. Highway 6, and to residents of Wellington, Price, and other local communities.

Nine Mile Canyon and the Nine Mile Canyon ACEC, an area of the STSA of particular concern for visual values, are managed as VRM Class II (BLM 2005e). The ACEC designation recognizes the scenic values of the canyon area. Nine Mile Canyon contains dramatic topography of high canyon walls, with steep side canyons and isolated buttes, mesas, and outcrops. A lush riparian zone of willow and cottonwood is found on the canyon bottom. Water features include the stream and beaver ponds. Farms and ranches provide a rural appearance to an otherwise natural-looking landscape. Other cultural modifications include roads, trails, and pipeline. The canyon walls contain numerous petroglyphs and other cultural resource sites visible from the county road that follows the canyon bottom. Within Nine Mile Canyon is the greatest concentration of rock art sites in the United States. The Nine Mile Canyon Scenic Byway, a State Scenic Byway and a BLM Backcountry Byway, follows the length of Nine Mile Canyon (BLM 2004a). Nine Mile Creek has been determined to be eligible for WSR designation, in part because of its outstandingly remarkable scenic value (BLM 2004b, 2005c); however, it was determined not to be suitable under the relevant test and was not classified as a WSR in the 2008 Vernal RMP.

The far western portion of the Sunnyside STSA overlaps the Lears Canyon ACEC. The far eastern portion of the main Sunnyside STSA parcel includes small portions of the Jack Canyon and Desolation Canyon WSAs. A small STSA parcel is located entirely within the two WSAs. Part of the BLM portion of the STSA is bordered by a USFS roadless area to the north.

3.8.3.9 Tar Sand Triangle STSA

The Tar Sand Triangle STSA is located in an area characterized by flat-topped mesas and steep-walled canyons. Elevation ranges from 4,800 to nearly 7,000 ft. The margins have stair-step topography, with mesas and buttes beyond the cliffs. The area is remote and very rugged, with relief up to 3,700 ft. Vegetation is sparse, with some desert shrubs and grasses, as well as scattered pinyon-juniper (BLM 1984b).

The high-quality scenic and recreational resources in and around the STSA are nationally significant (BLM 1984b). A significant portion of the STSA is in Glen Canyon NRA, and small portions are in Canyonlands National Park. More than half of the remainder of the STSA overlays the Fiddler Butte and French Spring–Happy Canyon WSAs. Scenic attractions in the STSA and the surrounding area constitute a major attraction for recreational users. Scenic attractions include unique landforms resulting from erosion, with flat-topped mesas, buttes, rugged cliffs, and canyons and slickrock formations. Mesas throughout the STSA offer views of the surrounding canyons and mountain ranges, such as the dramatic colorful landforms of the Maze portion of Canyonlands National Park and Glen Canyon NRA, the varied landforms of the deeply incised canyons of the Colorado and Dirty Devil Rivers, and Lake Powell. Panoramic views of the Colorado River canyons from the Orange Cliffs on the eastern edge of the STSA are particularly noteworthy, as is the staircase of terraces and vertical cliffs from the mesa tops to the bottom of Happy Canyon. Detached, sculptured buttes, monuments, and minarets are also found within the STSA (BLM 1984b).

Much of the BLM-managed public land in the STSA has been inventoried as VRI Class III or Class IV, except Happy Canyon and French Spring, which are VRI Class II. Smaller areas inventoried as VRI Class II are located south of Happy Canyon. Outside Glen Canyon NRA, most of the STSA has been designated VRM Class 1 because most of the STSA land outside the NRA is part of the French-Spring-Happy Canyon or Fiddler Butte WSAs. The remainder of the STSA land outside the NRA is predominantly VRM Class II, with lesser amounts of VRM Class III and IV lands, as indicated in the Richfield RMP (BLM 2008i).

3.8.3.10 White Canyon STSA

Much of the White Canyon STSA is a mesa incised by White Canyon (Figure 3.8.3-2). The southern portion of the STSA has bench and slope topography. Around the tar sands deposits, the ground slopes to the west, with elevations ranging from approximately 6,100 ft on the northeast end of the STSA to about 4,800 ft on the southwestern end. White Canyon is about 6 mi wide where it bisects the STSA, but much of the STSA is in Short Canyon (a side canyon of White Canyon) (BLM 1984b).Vegetation is sparse; there is a mixture of desert shrubs on the benches and scattered cottonwood riparian communities in the canyons.

FIGURE 3.8.3-2 White Canyon Bridge on State Route 95, San Juan County, Utah

The scenic value of the STSA is high. The STSA contains highly scenic canyon landforms, eroded through colorful sandstone layers that contrast pleasingly with the shrub and pinyon-juniper vegetation. The southern portion of the STSA is crossed by the Bicentennial Scenic Byway (a segment of Highway U-95, designated as a Utah State Scenic Byway) in the Scenic Highway Corridor ACEC. This ACEC includes a portion of the White Canyon viewshed (BLM 1984b). White Canyon is managed as VRM Class II (BLM 1987b). A portion of the Dark Canyon WSA is adjacent to the northwest boundary of the White Canyon STSA. At its closest point, Glen Canyon NRA is approximately 2 mi from the STSA.

3.9 CULTURAL RESOURCES

Cultural resources include archaeological sites and historic structures and features that are addressed under the NHPA, as amended (P.L. 89-665). Cultural resources also include

National Register Criteria for Evaluation (36 CFR 60.4)[a]

The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or

B. that are associated with the lives of persons significant in our past; or

C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. that have yielded or may be likely to yield, information important in prehistory or history.

[a] Additional *criteria considerations* are also provided in 36 CFR 60.4.

traditional cultural properties, that is, properties that are important to a community's practices and beliefs and that are necessary for maintaining the community's cultural identity. Cultural resources refer to both man-made and natural physical features associated with human activity and, in most cases, are finite, unique, fragile, and nonrenewable. Cultural resources that meet the eligibility criteria for listing on the *National Register of Historic Places* (NRHP) are historic properties (see text box). Federal agencies must take into consideration the effects on such properties of any undertakings under their direct or indirect jurisdiction before they approve expenditures or issue licenses.

Cultural resources on BLM-administered land are managed primarily through the application of the laws identified in Appendix D. As required by Section 106 of the NHPA, BLM offices work with land use applicants to inventory and evaluate cultural resources in areas that may be affected by proposed development. The BLM has established a cultural resource management program as identified in its 8100 Series manuals and handbooks (see Section D.2 in Appendix D). The goal of the program is to locate, evaluate, manage, and protect cultural resources on public lands. (See Section 3.1, Land Use, for a description of designated ACECs, some of which are designated specifically to protect cultural resources.) Guidance on how to apply the NRHP criteria to evaluate the eligibility of sites located on public lands is provided in numerous documents prepared by the NPS and in the BLM 8100 Series manuals and handbooks. Further guidance on the application of cultural resource laws and regulations is provided through the 2012 BLM National PA and State Protocols developed among the BLM, the National Conference of SHPOs, and the Advisory Council on Historic Preservation, and through state-specific PAs concerning cultural resources.

Although site-specific information regarding cultural resources would need to be collected to define the affected environment of an individual project, the types of sites listed on the NRHP in the broad study area for this PEIS include archaeological sites, historic buildings, bridges, historic trails, prehistoric dwellings, historic districts, water features (e.g., canals and ditches), and cultural landscapes. (See also Section 3.8 for a brief discussion of National Historic and Scenic Trails and other conservation areas established under the NLCS with a visual or scenic component.) A Class I cultural resource overview describing, in general, the types of resources known to be present in the oil shale and tar sands study area has been prepared in support of this PEIS and is summarized below for each of the oil shale basins and STSAs (O'Rourke et al. 2012).

3.9.1 NHPA Section 106 Compliance

Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA) requires the heads of federal agencies to take into account the effects of undertakings on any "district, site, building, structure, or object" that is included in or eligible for inclusion in the NRHP (historic properties), and to provide the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment.

All stages of oil shale and tar sands development (see text box in Section 1, Chapter 1) represent federal undertakings that are subject to the requirements of Section 106 of NHPA. The BLM will meet its responsibilities for Section 106 compliance at these various stages as follows.

3.9.1.1 Land Use Plan Allocation

Undertaking: This PEIS analyzes the effects of allocating BLM lands as open or closed to applications for leasing. See Section 7.7 for a discussion of the findings of this analysis. Once the Record of Decision is signed, the BLM may accept applications to lease land for the commercial production of oil shale/tar sands resources. This PEIS does not evaluate impacts from future leases or project proposals, nor does it authorize any such leases or projects. Nothing in this land allocation decision constrains the BLM from approving, modifying, or denying any future lease application based on review and evaluation of that application with regard to the requirements of NHPA and other pertinent laws, regulations, and policies.

Analysis of Effects: The BLM is analyzing existing cultural resource information and consulting with affected tribes, State Historic Preservation Officers, and other interested parties, as required (36 CFR 800.2), to determine the effects of the decision to allocate certain BLM lands as open or closed to oil shale and tar sands leasing and development. See Section 7.7 for a discussion of the findings of this analysis. The BLM's determination will include consideration of the following:

- It is not known whether current technologies or new technologies might be employed in the future. Therefore, in this PEIS the BLM can only provide a very general analysis of the types of resources that might be encountered during development, the types of impacts that might be sustained based on current technology, and recommendations for mitigation of those possible impacts should they occur.

- The analyses in this PEIS do show that cultural resources are likely to be present within areas allocated as open to lease application. The BLM is required to consider effects on these resources during the lease application and subsequent project development phases, when actual effects on known cultural and tribal resources can be analyzed based on defined technologies and activities, as part of its obligations under Section 106 of NHPA and other applicable laws, regulations, and policies.

- As part of the land use planning exercise, the BLM has decided to exclude from allocation all NLCS (i.e., historic trails[18]) and ACEC units, such as Nine Mile Canyon (Utah) and Duck Creek (Colorado) that have significant cultural values; and National Historic Landmarks (Table 3.9.1-1).

- The allocation decision analyzed in this PEIS authorizes the BLM to accept applications for leases for oil shale/tar sands development. The allocation decision does not constrain BLM managers with regard to any future decision to approve, modify, or deny such applications. Subsequent actions that derive from the decision to allocate lands as open to oil shale/tar sands leasing and development must comply with Section 106 of NHPA as well as all other pertinent laws, regulations, and policies.

3.9.1.2 Leasing

Undertaking: An applicant may submit to the BLM a proposal to lease certain lands for development. The decision to lease certain lands requires compliance with all relevant laws, regulations, and policies including, but not limited to, full compliance with the requirements of Section 106 of NHPA. Subsequent to the required analyses, the BLM may approve, modify, or deny the lease application. It is likely that if approved, the lease application would include stipulations with regard to use of the lease.

Analysis of Effects: When the BLM is considering a lease application, its responsibilities under NHPA Section 106 and other federal requirements include, but are not limited to, the following:

- Compliance with all tribal consultation and government-to-government responsibilities under various authorities including departmental and internal agency policies.

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[18] National Trails are officially established under the authority of the National Trails System Act (NTSA), P.L. 90-543, which became law October 2, 1968. The Act and its subsequent amendments authorized creation of a national system of trails and defined four classes of trails: National Scenic Trails, National Historic Trails, National Recreation Trails, and Connecting or Side Trails. In addition to the NTSA, the NHPA, NEPA, and the FLPMA are important authorities that support trail management. The trails within the study area and on BLM-administered public lands are National Historic Trails and are managed as part of the NLCS. The National Historic Trails that cross the most geologically prospective oil shale area are listed in Table 3.9.1-1. National Trail Corridors that have been established through BLM Field Office RMPs are excluded from future leasing for oil shale development (Section 2.3.3). Where these corridors have not been established through an RMP, the BLM policy is that an “area of potential impact” would be determined through an inventory, where appropriate, and potential impacts to trail resources would be analyzed prior to leasing, and would be mitigated as necessary. Some additional discussion of National Historic Trails is included in Sections 3.1 (Land Use) and 3.8 (Visual Resources).

TABLE 3.9.1-1 Cultural Resource Exclusion Areas Intersecting Oil Shale or Tar Sands Areas

		ACEC Acres		
Exclusion Area	Field Office(s)	Total	Within Oil Shale Areas	Within STSAs
ACECs				
Colorado				
Duck Creek[a]	White River	3,425.8	3,425.8	0.0
Dudley Bluffs[a]	White River	1,628.2	1,628.2	0.0
East Fork Parachute Creek	Colorado River Valley	6,566.1	1,289.4	0.0
Northwater Creek	Colorado River Valley	1,961.9	1,591.9	0.0
Ryan Gulch[a]	White River	1,436.4	1,436.4	0.0
Trapper Creek	Co. River Valley, White River	2,844.0	1,418.1	0.0
		17,862.4	10,789.7	0.0
Utah				
Copper Globe	Price	128.6	0.0	128.6
I-70 Scenic Highway	Price	45,631.3	0.0	4,369.3
Lears Canyon	Vernal	1,377.8	0.0	889.7
Lower Green River[a]	Vernal	9,430.2	7,683.6	0.0
Nine Mile Canyon[a]	Vernal and Price	48,151.0	539.2	12,562.8
Pariette Wetlands[a]	Vernal	10,635.2	6,523.1	2,254.6
San Rafael Canyon	Price	54,144.7	0.0	22,227.6
San Rafael Reef	Price	84,084.6	0.0	4,760.6
Segers Hole	Price	NA	NA	NA
Sid's Mountain	Price	61,430.5	0.0	215.0
Temple Mountain	Price	2,446.0	0.0	2,439.3
		1,522,274.8	199,521.1	328,938.2
Wyoming				
Greater Red Creek	Rock Springs	175,240.0	44,656.9	0.0
Greater Sand Dunes	Rock Springs	41,644.2	256.5	0.0
Pine Springs	Rock Springs	6,054.9	6,054.9	0.0
Special Status Plant Species[a]	Rock Springs, Kemmerer	1,009.9	140.3	0.0
White Mountain Petroglyphs	Rock Springs	21.7	21.7	0.0
		223,970.6	51,130.3	0.0
National Historic Trails[b]				
Wyoming				
Mormon National Historic Trail	Rock Springs, Kemmerer			
Pony Express National Historic Trail	Rock Springs, Kemmerer			
Oregon/California National Historic Trail	Rock Springs, Kemmerer			

a ACECs open for oil and gas leasing under Alternative 1 but closed to leasing under Alternatives 2, 3, and 4.

b Acreages are not available for the intersection of National Historic Trails and oil shale areas due to the lack of definite boundaries on the trails.

- Tribal consultation with regard to the BLM's responsibilities under NHPA, which would emphasize the need to identify and evaluate places of traditional religious or cultural importance.

- Identification and evaluation of cultural resources sufficient to support the analysis of the effects of issuing a lease. This effort includes an analysis of existing overview information and a current records and literature search. A Class II or Class III inventory may also be required, if necessary to determine the undertaking's effect on historic properties.

- Identification of measures to avoid, minimize, or mitigate any adverse effects from the decision to lease, and incorporation of these measures as stipulations in the lease or as otherwise appropriate. The BLM can also decide that the importance of a historic property outweighs the development of the oil shale/tar sands resource and deny the application.

3.9.1.3 Project Development

Undertaking: An applicant must submit a detailed plan of development to the BLM for review prior to any project approval. At this time, the BLM will require a detailed review and analysis of the effects of specific actions on specific resources in compliance with Section 106 of NHPA, as well as all other pertinent laws, regulations, and policies. As a result of these analyses, the BLM is required to identify measures to avoid, minimize, and mitigate adverse effects on cultural and tribal resources as conditions of approval of the project.

Analysis of Effects:

- Tribal consultation under various authorities will continue throughout this stage, especially as the possible effects of the development become apparent. Consultation will likely focus on defining specific effects to resources of concern, and identifying measures to avoid, minimize, or mitigate those effects.

- The BLM will continue consultation with appropriate consulting parties as it further defines the area of potential effect, the resources likely to be affected, and measures to avoid, minimize, and mitigate adverse effects from project development.

- It is at this stage that detailed field review will take place, including Class III cultural resource inventories, visual resource inventories, and other site specific reviews as needed. Any inventory data gathered during the leasing stage will be incorporated into field studies occurring at the project development stage.

According to regulation and policy, the BLM may conclude its Section 106 consideration with a Programmatic Agreement or Memorandum of Agreement among the various consulting parties. Any conditions or stipulations needed to protect the cultural resource values in the area will be attached to the plan of development prior to approval.

3.9.2 Piceance Basin

3.9.2.1 Prehistoric Context for Archaeological Sites, Features, and Structures

There is archaeological and ethnographic evidence to suggest that the Piceance Basin was inhabited and visited on a regular basis by human populations for more than 12,000 years. Abundant native faunal and floral resources were available to early human populations as part of a seasonal round of subsistence. Permanent seasonal water sources within the area attracted numerous animal species, including mule deer.

The cultural history for northwestern Colorado is divided chronologically into four major time periods, or eras, as defined by Reed and Metcalf (1999). These eras include the Paleoindian era (11,450 to 6,400 B.C), the Archaic era (6,400 to 400 B.C.), the Formative era (400 B.C. to A.D. 1300), and the Protohistoric era (A.D. 1300 to 1880). Each time period yields distinctive sets of artifacts and archaeological features. Large lanceolate points used for hunting bison and other big game are characteristic artifacts of Paleoindian Period sites and are usually found as isolated artifacts or in association with later period sites. The Archaic era represents a shift in diet and settlement patterns to a greater reliance on gathering wild plant foods and hunting smaller game.

During the Formative era, there was a shift from the seasonal hunter-gatherer subsistence strategy toward that of early farming practices. However, hunting and gathering continued to play a major role in the economy, and use of the bow and arrow was introduced during this period. In northwestern Colorado, the Formative era is represented by two distinct traditions, the Fremont and Aspen. The development of horticulture is unique to the Fremont. The main crop of the Fremont in general was corn, but cheno-ams appear to have been important in the Piceance Basin. The Fremont is also associated with the introduction of pottery and the appearance of unique rock art and modeled clay figurines. The Fremont sites in the Piceance Basin and vicinity would most closely relate to a Plains-influenced variant of the Fremont known as the Uinta Fremont. Important characteristics of the Uinta variant include the presence of shallow pit-houses and freestanding structures, and the complete absence of Fremont clay figurines. Fremont sites include rock art sites, open and sheltered artifact scatters, and architectural sites. According to Reed and Metcalf (1999), no confirmed Fremont pit-houses have been found in the study area. Contemporaneous with the Fremont culture, the Aspen Tradition is assigned to nonhorticultural groups residing in the region during the Formative era; the sites are similar with the two exceptions of no evidence of farming and no Fremont-style pottery. It is not expected that the prehistoric populations practiced horticulture in the Piceance Basin per se, because of the relatively short growing season and inadequate soil conditions. However, horticultural sites are found very near to the basin to the west and northwest.

The Protohistoric era is defined by what appears to be a gradual ending to the Fremont horticultural lifeways and the return to a more mobile, hunter-gatherer life style similar to that of the earlier Archaic era. The cause of this shift is unknown, but it is speculated that either an outside group migrated in, replacing or mixing with the Fremont and Aspen groups, or the Fremont chose to abandon horticulture. Most structures found at Protohistoric sites are wikiups, or brush structures. In the later portion of the Protohistoric era (after 1650), the horse is introduced and tipi rings appear in the archaeological record. The Protohistoric hunter-gather groups were ancestral Ute or Shoshone. Both groups ranged widely. The Shoshone wintered in the Wind River and Green River Valleys, but their seasonal round of hunting and gathering could take them far afield. The Yampa Valley was a favored area for harvesting wild plants and some Shoshone bands were reported as far north as Canada and as far south as Mexico (Baker et al. 2007; BLM 2004g). Ute and Shoshone continued to hunt and gather resources in the study area even after their official removal to reservations in the mid-to-late 19th century.

3.9.2.2 Historic Context for Archaeological Sites, Features, and Structures

The historic context for northwestern Colorado is presented in the Class I Cultural Resource Overview (O'Rourke et al. 2012) and is summarized briefly here. Historic period sites in this region broadly follow some general themes, notably early exploration and fur trade, ranching and settlement, and mining. European exploration of this region of Colorado began in 1776 with two Spanish missionaries (Franciscan friars Dominguez and Escalante) looking for a new route from New Mexico to California missions that avoided resistance from Hopi Indians in Arizona. They encountered Ute bands no further north than the Colorado River drainage. Shoshone or Comanche appear to have resided to the north and west of the Ute. Rock art with elements of the "Plains Biographic Style" associated with the Shoshone or Comanche has been found in Rio Blanco County (Martin and Miller 2009a,b; Ott 2010). Dominguez and Escalante found no new route, and the area was not visited again until the 1820s when the fur trade began to flourish in the region. Both the Ute and the Shoshone bands were actively involved in the fur trade; their interaction with one another was sometimes friendly and sometimes hostile (Baker et al. 2007; BLM 2004g). In addition to the use of the area by trappers, a number of explorers surveyed the area, but their descriptions of northwestern Colorado are limited to references to its being dry and useless. However, the discovery of gold in the Denver area in 1859 brought many prospectors to Colorado. A subsequent survey of the northwestern region a decade later indicated that while the area could not support agriculture without large-scale irrigation, it could support ranching. This in effect opened up the area to ranching, an economic practice that continues today. As more and more ranches and small settlements were being established, pressures with the existing bands of Ute Indians began to escalate as traditional Ute hunting territory was being encroached upon. Several treaties were established between 1849 and 1868 and culminated in the placement of the Ute and Shoshone bands onto reservations.

Large-scale open range cattle ranching was at its peak in the region between 1880 and the early 1900s. Sheep herding was also getting a start as a local industry. "Sheep wars" broke out between 1890 and 1920 as the sheep started to encroach on cattle country. This prompted a reorganization of grazing rights in Colorado and the introduction of land allotments in 1934 through the establishment of the Taylor Grazing Service to control land use. These events essentially ended open range cattle grazing and significantly slowed down the process of additional homesteading in this area. It also eventually resulted in the formation of the BLM, which controls grazing rights on public lands through the issuance of permits to this day.

Coal and oil were known to be present in the region as early as 1870 and 1890, respectively. Most of the coal mining was conducted east and south of the Piceance Basin. It was not until World War II that the demand for oil sparked sufficient interest to get the industry underway in this region. In addition to the oil, oil shale deposits present in the Piceance Basin, particularly in the Mahogany Zone, were getting attention from industry, as different companies experimented with various recovery techniques. By 1920, DeBeque, Colorado, was known as the shale oil capitol of the United States. However, no economical technique was discovered to recover the oil from the shale, and the industry experienced a series of ups and downs as experimentation continued. In the late 1970s and early 1980s, there was a surge in interest, but this too was short-lived and resulted in some serious economic issues for the region.

3.9.2.3 Surveys and Sites in the Study Area

In the most geologically prospective oil shale area of the Piceance Basin study area, a total of 849 different surveys have occurred, according to the Colorado SHPO database. These investigations are predominantly Class III intensive field surveys. Spatial analyses of the GIS data revealed that approximately 162,308 acres in the Piceance Basin have been subjected to some level of survey.

The total number of recorded sites within the geologically prospective oil shale areas of the Piceance Basin, on the basis of GIS data provided by the Colorado SHPO in 2011, is 2,059. The number of sites that correspond to each site type is shown in Table 3.9.2-1; not all sites have been categorized as a particular site type in the database. Duplicates are also inherent in this data since many sites have both prehistoric and historic components. For future project-specific analyses, the data for sites in a specific project area can be collected from data in the site forms on file at the Colorado SHPO. In addition, the numbers of sites that have been attributed eligibility status and entered into the database are presented in Table 3.9.2-2.[19]

Cultural resource sensitivity maps for each of the oil shale basins were developed on the basis of the relationships of known prehistoric sites and soil families (O'Rourke et al. 2012). High-sensitivity areas correspond to lower elevations in the central and northern portions of the Piceance Basin. Areas in the middle and higher elevations in the southern half and western edge of the basin are considered areas of low site frequency.

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[19] The cultural resource information obtained from the various historic preservation offices represents a snapshot in time of the information available. These data change daily as new information is collected and processed. All future projects requiring Section 106 review will have to complete a thorough investigation of existing site and survey data beyond that available strictly in the GIS records maintained by the SHPO. The data used for the large-scale production of the Class I Overview, completed as part of the PEIS, did not evaluate paper records of backlogged data or recent submittals that had not yet been entered digitally. Existing data, reviewed in this PEIS, do serve to provide a sample of the main types of sites that occur in the study area.

3.9.3 Uinta Basin

3.9.3.1 Prehistoric Context for Archaeological Sites, Features, and Structures

The cultural history of prehistoric populations in the Uinta Basin includes four major time periods: the Paleoindian Period (10,000 to 6,000 B.C), the Archaic Period (6,000 B.C. to A.D. 500), the Formative Period (A.D. 500 to 1300), and the Protohistoric Period (also known as the Shoshonean or Numic Era) (A.D. 1300 to 1850). Each time period yields distinctive sets of artifacts and archaeological features. Large lanceolate points used for hunting big game, such as giant bison and mammoth, are characteristic artifacts of Paleoindian Period sites and are usually found as isolated artifacts or in association with later period sites. The Archaic era represents a shift in diet and settlement patterns from a highly mobile hunting lifestyle to a greater reliance on gathering wild plant foods and hunting smaller game. The discussion in Section 3.9.2.1 regarding the Formative Period in Colorado also generally applies. This period is when horticulture comes into practice, as well as widespread pottery use. Modeled clay figurines, rock art, and basketry are also part of the archaeological record. The lifestyle during this period is more sedentary, and semisubterranean pit-houses are being constructed. The Uintah Fremont, also discussed in Section 3.9.2.1, is a local variant of the Fremont tradition during this period that is also present in the Uinta Basin. The Protohistoric Period refers to the period when European influence and artifacts first make an impact on native populations, including the introduction of the horse. In the Uinta Basin, as in the Piceance Basin, the populations revert to a more Archaic hunting and gathering lifestyle and cease agricultural practices. Very little is known about this period in the Uinta Basin. The prehistoric context is described in greater detail in the Class I Cultural Resource Overview (O'Rourke et al. 2012) prepared in support of this PEIS.

TABLE 3.9.2-1 Site Types of Known Archaeological Sites in the Piceance Basin, Colorado

Site Type	Number of Sites
Historic; architecture	65
Historic; isolated feature	7
Historic; isolated find	65
Historic; road or trail	13
Historic; all other site types	128
Total historic sites and isolated finds	278
Isolated feature	8
Isolated find	1,033
Open architecture	79
Open camp	269
Open lithic	284
Rock art	3
Shelter camp	9
Stone quarry	1
Other/Unknown	35
Total prehistoric sites and isolated features	1,721
No information	60

TABLE 3.9.2-2 Eligibility Status of Known Archaeological Sites in the Piceance Basin, Colorado

Eligibility Status	Number of Sites
Listed	1
Eligible	112
Not eligible	1,690
Eligibility undetermined	256
Total number of sites	2,059

3.9.3.2 Historic Context for Archaeological Sites, Features, and Structures

The historic context for the Uinta Basin is presented in the Class I Cultural Resource Overview (O'Rourke et al. 2012) and is summarized briefly here. Historic period sites in this region broadly follow the themes of early exploration and fur trade; ranching and settlement; and mining. The early history of the Uinta Basin is essentially the same as that for northwestern Colorado, regarding early Spanish exploration and the establishment of the fur trade (Section 3.9.2.2). Sites related to these activities are relatively rare, but at least one early trading post (Fort Davy Crockett) has been located and archaeologically excavated in the area. However, unlike other parts of the west, but similar to northwestern Colorado, the fur trade did not lead to settlement; it mostly led to further exploration and mapping in search of possible railroad routes through the area. The first Euroamerican settlement of the region coincides with the establishment of the Uintah and Ouray Reservation. A few small cattle ranches were established in the area, but these tended to stay close to the foothills of the Uinta Mountains in the northern portion of the basin. In addition, during the latter part of the nineteenth century Mormons began settling along the Green River. Irrigation was necessary to the survival of any farming practices in this arid region, resulting in the construction of a network of canals and reservoirs. Sheep raising also grew to be an important industry in the early part of the twentieth century. The mining of gilsonite and oil shale, as well as oil and gas production, are the other historic industries of note within the Uinta Basin. Evidence of these practices and the roads, pipelines, and rail lines that support them are scattered throughout the area. Several gilsonite-related mining towns are now ghost towns.

3.9.3.3 Surveys and Sites in the Study Area

In the most geologically prospective oil shale area of the Uinta Basin study area, a total of 3,651 different surveys occurred, according to GIS data obtained from the Utah SHPO in 2011. These investigations are predominantly Class III intensive field surveys. Spatial analyses of the GIS data reveal that approximately 291,572 acres in the Uinta Basin have been subject to some survey. These acreage numbers underestimate the amount of land surveyed because they do not account for a number of linear surveys that have been conducted in the region; linear surveys of approximately 4,472 mi have also been conducted in the Uinta Basin.

The total number of recorded sites within the geologically prospective oil shale areas of the Uinta Basin, based on GIS data provided by the Utah SHPO in 2011, is 3,058. These sites are identified as having prehistoric and/or historic components tied to a particular period or group affiliation, unlike site data from Colorado and Wyoming, which are classified by site type or function. Details regarding prehistoric and protohistoric affiliation are not presented here. Duplicates are inherent in this data as many sites have both prehistoric and historic components; therefore, a site total is not meaningful and is not presented in Table 3.9.3-1. In addition, the numbers of sites that have been attributed eligibility status are presented in Table 3.9.3-2. There are many sites for which no data regarding site type or eligibility have been entered into the system.[20]

Cultural resource sensitivity maps for each of the oil shale basins were developed on the basis of relationships of known prehistoric sites and soil families (O'Rourke et al. 2012). High-sensitivity areas correspond to the northwestern part of the Uinta Basin along a section of Green River and including adjacent uplands. Moderate-sensitivity areas extend across the central part of the basin and include the lower reaches of the White River Valley. According to the analysis completed for the EIS, areas of low sensitivity occur in upland tracts, mostly away from water, in the western, northeastern, and southeastern parts of the Uinta Basin.

TABLE 3.9.3-1 Cultural Affiliations of Known Archaeological Sites in the Uinta Basin, Utah

Site Type	Number of Sites
Prehistoric	
Archaic	90
Fremont	36
Late Prehistoric	15
Paleoindian	7
Protohistoric	43
Unknown/other	690
No information available	9
Historic	
European/American	694
Ute/Paiute/Navajo	34
Unknown Affiliation	47

TABLE 3.9.3-2 Eligibility Status of Known Archaeological Sites in the Uinta Basin, Utah

Eligibility Status	Number of Sites
List/ Nominated	20
Eligible/NR Quality	533
Not eligible	1,050
Eligibility undetermined	94
Data not available	1,361
Total number of sites	3,058

3.9.4 Green River and Washakie Basins

3.9.4.1 Prehistoric Context for Archaeological Sites, Features, and Structures

The cultural history of prehistoric populations in southwestern Wyoming includes four major time periods: the Paleoindian Period (10,000 to 6,500 B.C), the Archaic Period (6,500 B.C. to A.D. 0), the Late Prehistoric Period (A.D. 0 to 1500), and the Protohistoric Period (A.D. 1500 to 1800). Each time period yields distinctive sets of artifacts and archaeological features. Large lanceolate points used for hunting megafauna, such as giant bison and mammoth, are characteristic artifacts of Paleoindian Period sites and are usually found as isolated artifacts or in association with later period sites. Smaller dart points and early house-pits are characteristic of the subsequent and long-lived Archaic Period. The two main technological advances that mark the Late Prehistoric Period are the bow and arrow and the introduction of pottery, indicative of growing populations and a more sedentary (less mobile) lifestyle. The Protohistoric Period refers to the period when European influence and artifacts first made an

[20] The cultural resource information obtained from the various historic preservation offices represents a snapshot in time of the information available. These data change daily as new information is collected and processed. All future projects requiring Section 106 review will have to complete a thorough investigation of existing site and survey data beyond that available strictly in the GIS records maintained by the SHPO. The data used for the large-scale production of the Class I Overview, completed as part of the PEIS, did not evaluate paper records of backlogged data or recent submittals that had not yet been entered digitally. Existing data, reviewed in this PEIS, do serve to provide a sample of the main types of sites that occur in the study area.

impact on native populations, including the introduction of the horse. The prehistoric context is described in greater detail in the Class I Cultural Resource Overview (O'Rourke et al. 2012) prepared in support of this PEIS.

3.9.4.2 Historic Context for Archaeological Sites, Features, and Structures

The historic context for southwestern Wyoming is presented in the Class I Cultural Resource Overview (O'Rourke et al. 2012) and is summarized briefly here. Significant historic period sites in southwestern Wyoming broadly follow some general themes, notably fur trade; settlement and transportation; ranching; and oil and coal mining. The area was heavily used by early fur trappers. Sites related to this activity are relatively rare (e.g., early trading posts, annual meeting, or rendezvous, locations; and individual trappers' camps). However, the trails the trappers and Native American populations used were noted, and this information was passed along to others to subsequently form the main trails for westward expansion and migration.

The trail systems and the emigrant sites associated with these trails are a very important component of the history of this region. The Oregon Trail and its various cutoffs and deviations cut across a large portion of the Green River Basin; many of these trail segments have been determined significant historic properties. Portions of this trail system also coincide with other key events (establishment of Mormon settlement of Utah, California Gold Rush, and Pony Express) that result in numerous historic sites associated with these events (e.g., camps, stage stations, rock inscriptions, and wagon ruts). Similarly, the Overland, or Cherokee, Trail cuts across both the Washakie and Green River Basins. The first transcontinental railroad (Union Pacific) cuts across southern Wyoming following the Overland Trail route, as does the transcontinental Lincoln Highway, the first road constructed for automobile use in the state. Associated with these developments are tent towns, stage stations, wagon roads, and various small related sites identifiable by a scattering of historic artifacts.

Ranching was also a significant industry in southwestern Wyoming, especially once the railroad was established and livestock could be shipped. From the main east–west rail line, ranches spread north and south, up and down the Green River and its tributaries. Cattle raising provided the single greatest impetus to settlement away from the main line of the Union Pacific and continues to be economically significant to the state. Sheep raising was also an important factor in the settlement and economic development of Wyoming. Sheep ranching rendered semiarid land economically productive and served to broaden the economic base that led to the growth and development of regional towns. Conflicts between cattle and sheep ranchers in the 1890s eventually were diminished as the open range was fenced, and as federal agencies later regulated the use of public range lands. Numerous homesteads and ranches have been recognized as historic sites in the Green River Basin. Several irrigation ditches have been identified as potential historic engineering structures.

Sites related to the history of mining coal deposits and exploiting oil seeps are also important to the history of the region. Many of the early development sites coincide with the development of the emigrant trails. When the Overland Trail was laid out, some stage stations along the route appear to have been sited near coal outcrops specifically so that fuel would have been available for the blacksmith shops and for general heating purposes. Later, the Union Pacific rail line was routed near these readily accessible coal seams, since the fuel was needed to power the locomotives. Outlying prospecting pits, old mine shafts, and abandoned camps are some of the physical reminders of historic early mining operations in the area.

3.9.4.3 Surveys and Sites in the Study Area

Past archaeological investigations in the most geologically prospective oil shale area of the Green River Basin study area total 4,315, according to the Wyoming Cultural Records Office (WYCRO) database. In the Washakie Basin, 535 different survey blocks or linear segments underwent archaeological investigation (predominantly Class II sampling and Class III intensive field surveys). Spatial analyses of the GIS data reveal that approximately 139,222 acres in the Green River Basin and approximately 29,053 acres in the Washakie Basin have been subject to some survey. These acreage numbers underestimate the amount of land surveyed because they do not account for a number of linear surveys that have been conducted in the region.

The total number of recorded sites within the geologically prospective oil shale areas of the Green River and Washakie Basins based on GIS data provided by the Wyoming SHPO in 2011 is 7,412. This total includes 6,465 sites in the Green River Basin and 947 sites in the Washakie Basin. A variety of different site types are represented. The number of sites that correspond to each site type is shown in Table 3.9.4-1. In addition, the numbers of sites that have been attributed eligibility status are presented in Table 3.9.4-2.[21]

Cultural resource sensitivity maps for each of the oil shale basins were developed on the basis of relationships of known prehistoric sites and soil families (O'Rourke et al. 2012). High-sensitivity areas in the Green River Basin correspond to soils along the Green River and Black's Fork and soils in open or somewhat broken terrain where sand dunes are present. High-sensitivity areas in the Washakie Basin correspond to soils at low elevations in the eastern part of the basin. Areas of moderate sensitivity cover most of the uplands in the Green River Basin and in the western third of the Washakie Basin. Low site densities occur in the most highly elevated terrain around the edges of the Green River Basin and the elevated ridge and dissected plateau in the central portion of the Washakie Basin.

3.9.5 Special Tar Sand Areas in East-Central and Southeastern Utah

Most of the STSAs are located within or adjacent to the geologically prospective area for oil shale development in the Uinta Basin. For these areas, the prehistoric and historic context

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[21] The cultural resource information obtained from the various historic preservation offices represents a snapshot in time. These data change daily as new information is collected and processed. All future projects requiring Section 106 review will have to complete a thorough investigation of existing site and survey data beyond that available strictly in the GIS records maintained by the SHPO. The data used for the large-scale production of the Class I Overview, completed as part of the PEIS, did not evaluate paper records of backlogged data or recent submittals that had not yet been entered digitally.

TABLE 3.9.4-1 Site Types of Known Archaeological Sites in the Green River and Washakie Basins, Wyoming

	Number of Sites		
Site Type	In Green River Basin	In Washakie Basin	Total in Wyoming Study Area
Historic			
Exploration	1	0	1
General	207	50	257
Irrigation	11	0	11
Mining	3	1	4
Ranching	124	18	142
Transportation	272	28	300
Urban	13	0	13
Prehistoric			
Activity area	64	60	124
Habitation	2,810	155	2,965
Lithic	2,537	432	2,963
Open camp	333	193	526
Special[a]	70	10	80
Additional Site Types			
Historic Native American	2	0	2
Human remains/burials/cemeteries	6	0	6
Unknown/no information	18	0	18
Total number of sites	6,465	947	7,412

[a] The category “Special” includes rock alignments, cairns, stone circles, medicine wheels, rock art, rock shelters, buffalo and antelope kill sites, and ceremonial sites.

TABLE 3.9.4-2 Eligibility Status of Known Archaeological Sites in the Green River and Washakie Basins, Wyoming

	Number of Sites		
Eligibility Status	In Green River Basin	In Washakie Basin	Total in Wyoming Study Area
Eligible	1,431	217	1,718
Not eligible	3,339	316	3,655
Eligibility undetermined	1,682	344	2,026
Data not available	13	0	13
Total number of sites	6,465	947	7,412

presented in Sections 3.9.3.1 and 3.9.3.2, respectively, are applicable. The following is a summary of the contexts for those STSAs that are located farther south in central and southern Utah. Much of the discussion presented here is summarized from a highly relevant previous archaeological study conducted for a tar sands project in the 1980s (Tipps 1988). The prehistoric and historic context is described in greater detail in the Class I Cultural Resource Overview (O'Rourke et al. 2012) prepared in support of this PEIS.

3.9.5.1 Prehistoric Context for Archaeological Sites, Features, and Structures

The cultural history of prehistoric populations in central and southern Utah includes four major time periods: the Paleoindian Period (10,000 to 6,000 B.C.), the Archaic Period (6,000 B.C. to A.D. 500), the Late Prehistoric Period (A.D. 500 to 1300), and the Protohistoric Period (also known as the Shoshonean or Numic Era) (A.D. 1300 to 1850). Each time period yields distinctive sets of artifacts and archaeological features. Large lanceolate points used for hunting big game, such as bison and mammoth, are characteristic artifacts of Paleoindian Period sites, and are usually found as isolated artifacts or in association with later period sites. Isolated Paleoindian points have been recorded in the vicinity of the southern STSAs. The Archaic era represents a shift in diet and settlement patterns from a highly mobile hunting lifestyle to a greater reliance on gathering wild plant foods and hunting smaller game. Several rockshelters and caves in the region have been excavated and have greatly added to the regional understanding of the Archaic Period in terms of artifact typologies and chronologies.

The Late Prehistoric Period is when horticulture comes into practice, as well as widespread pottery use and use of the bow and arrow. Modeled clay figurines, rock art, and basketry are also part of the archaeological record. The lifestyle during this period is more sedentary, and storage and living structures (both pit dwellings and masonry structures) are being constructed. There is a great deal of archaeological debate concerning the various cultural traditions that have been proposed and surrounding the presence of both Fremont and Anasazi characteristics at many sites, so this description may be overly simplified. The San Rafael Fremont is a local variant of the Fremont cultural tradition found in Central Utah dating to this period; this tradition is distinct from the Uintah Fremont variant present in northeastern Utah and northwestern Colorado. The primary distinctions are the presence of stone-lined pit dwellings and adobe masonry structures and the pottery type; caves and overhangs were also used for storage and habitation. The Sunnyside and San Rafael Swell STSAs are located within the area considered to be associated with the San Rafael Fremont. Another cultural tradition of the Late Prehistoric Period that is present in the region is the Anasazi tradition linked to the Pueblo groups. This very complicated archaeological tradition with its many subperiods is used widely to describe the cultural chronology of the greater Southwest region of the United States. The Virgin, Mesa Verde, and Kayenta Anasazi are local variants of the Anasazi cultural tradition present in the southern portion of the state. The Circle Cliffs area is in a transition zone between the San Rafael Fremont and Virgin and Kayenta Anasazi cultures. The area of White Canyon and Tar Sand Triangle is most closely linked with the Kayenta and Mesa Verde Anasazi, although Fremont rock art is also common in the area. Anasazi presence does not appear to be continuous during the Late Prehistoric Period in the vicinity of these southern STSAs. The Protohistoric Period refers to the period when European influence and artifacts first make an impact on native populations, including the introduction of the horse. The inhabitants of the region are primarily Numic-speaking groups ancestral to the Ute and Paiute, although there is some evidence of Navajo presence near the White Canyon area.

3.9.5.2 Historic Context for Archaeological Sites, Features, and Structures

Historic period sites in this region broadly follow the themes of early exploration and fur trade, ranching and settlement, and mining. Early exploration in the region was primarily by the Spanish, followed by Euroamerican trappers and traders. Prior to Euroamerican settlement, the Old Spanish Trail was the main route through the region used by trappers, traders, Indians, and slave traders (people who peddled captured Paiute women and children). Early settlement of the area was initiated by the arrival of the Mormons in Utah. Much of the early settlement focused on raising cattle and sheep. Concurrently with Mormon settlement, government exploration in search of possible routes for a transcontinental railroad and mail delivery was also conducted throughout the region. The area became the backdrop for the Black Hawk War, where settlements were raided by Utes, Paiutes, and Navajos. In addition, the area was known for cattle rustling and thievery in the late nineteenth century. Butch Cassidy and the Wild Bunch are known to have hidden away in this region, and several of their presumed escape routes follow old cattle and Indian trails. By the turn of the century, there was a shift in the economy from farming and ranching in Central Utah to coal mining coincident with the availability of the Denver and Rio Grande Western rail line. Oil was also drilled near the Green River. To the south, gold, silver, and copper mining became popular for a short time, followed by the mining of radioactive ore (e.g., uranium and radium). Near White Canyon, there was a mill constructed to process uranium ore from one of the richest uranium mines on the Colorado Plateau. A small settlement was established at the mouth of White Canyon, near the mill, to support the mining activities. In the twentieth century, large tracts of public lands were set aside for reclamation projects and recreational areas, including the construction of dams and reservoirs and the establishment of several National Monuments and National Parks.

3.9.5.3 Surveys and Sites in the Study Area

Within the 11 STSAs, a total of 883 different cultural resource surveys occurred, according to the Utah SHPO data obtained in 2011. These investigations are predominantly Class III intensive field surveys. Spatial analyses of the GIS data reveal that more than 140,927 acres within the STSAs have been subject to some survey. These acreage numbers underestimate the amount of land surveyed because they do not account for a number of linear and point surveys that have been conducted in the region; linear surveys of more than 1,813 mi have also been conducted within the 11 STSAs.

The total number of recorded sites within the 11 STSAs, based on GIS data provided by the Utah SHPO in 2011, is 2,587 sites. These sites are identified as having prehistoric and/or historic components tied to a particular period or group affiliation. Details regarding the prehistoric and protohistoric affiliation are not presented here. Many sites have both prehistoric and historic components. Cultural affiliations are listed in Table 3.9.5-1. The number of sites that

TABLE 3.9.5-1 Site Types of Known Archaeological Sites in the 11 Special Tar Sand Areas, Utah

	Number of Sites in Each STSA										
Cultural Affiliation	Argyle Canyon	Asphalt Ridge	Circle Cliffs	Hill Creek	P.R. Spring	Pariette	Raven Ridge	San Rafael Swell	Sunnyside	Tar Sands Triangle	White Canyon
Paleoindian	0	0	0	3	0	1	0	0	0	3	0
Archaic	0	1	15	18	9	2	0	0	14	13	0
Late Prehistoric	0	0	0	5	1	1	0	0	2	6	0
Fremont	0	1	5	20	11	2	3	3	127	2	0
Anasazi/Puebloan	0	0	8	0	0	0	0	0	0	3	0
Numic	0	0	10	6	0	1	1	0	1	3	0
Ute/Paiute/Shoshoni/Algonquin	0	0	0	0	9	0	0	0	3	1	0
Unknown Aboriginal	0	13	58	5	85	82	18	1	225	78	1
European/American	1	6	16	158	21	15	3	10	35	7	0
Historic Ute/Paiute	0	0	0	25	2	0	0	0	0	0	0
Unknown Historic	0	1	1	33	6	1	0	0	8	1	0
Multicomponent Prehistoric/Historic	0	4	11	17	8	4	4	2	10	1	0
No data	0	6	65	271	218	103	3	77	372	133	18
Total	1	32	179	601	370	212	32	93	797	251	19

have been attributed eligibility status is presented in Table 3.9.5-2. It should be noted that there are many sites for which no data regarding site type or eligibility have been entered into the system. In addition, some of the sites are the same as those recorded in the Uinta Basin because of the study area overlap.[22]

Cultural resource sensitivity maps for many of the STSAs were developed on the basis of relationships of known prehistoric sites and soil families (O'Rourke et al. 2012). However, complete sensitivity maps of all of the STSAs could not be developed from the soils data. Factors such as STSAs located within single soil families, archaeological surveys within STSAs limited to single soil families, and site frequencies that in some cases were not statistically different than expected for random distribution affected results for Argyle Canyon, Asphalt Ridge, Circle Cliffs, Raven Ridge, Sunnyside, and Tar Sand Triangle STSAs. Sensitivity maps were generated for the remaining six STSAs on the basis of nonrandom associations between soil families and site frequency. High-sensitivity areas composed large proportions of Argyle Canyon, Pariette, Sunnyside, and White Canyon. Moderate-sensitivity areas covered significant portions of Circle Cliffs, Hill Creek, P.R. Spring, and San Rafael. Low-sensitivity areas occupied major portions of Argyle Canyon, Asphalt Ridge, Hill Creek, P.R. Spring, Raven Ridge, Sunnyside, and Tar Sand Triangle STSAs. The specific soil families are presented in O'Rourke et al. (2012).

3.10 INDIAN TRIBAL CONCERNS

As with other ethnic groups, Native Americans often express concern for preserving their traditional lifeways, language, and religion. This is often expressed as concern for the preservation of and access to sites, resources, and places important to their heritage. These include, but are not limited to, traditional cultural properties (e.g., archaeological sites, funerary objects, culturally important animal species, medicinal plants, and sacred landscapes). Tribes also share areas of concern with the population as a whole (e.g., water rights, mineral rights, environmental protection, and economic development). For example, the Ute Indian Tribe (Uintah and Ouray Reservation) expressed concerns over effects on water quality and the possibility of subsidence from oil shale and tar sands development (Loosle 2012). Concerns specific to tribes must be identified by the tribes (Ott 2010). Government-to-government consultation with the tribes is essential for understanding the affected environment from a tribal perspective. Since tribes often see the world as an interconnected whole, in many cases it

[22] The cultural resource information obtained from the various historic preservation offices represents a snapshot in time of the information available. These data change daily as new information is collected and processed. All future projects requiring Section 106 review will have to complete a thorough investigation of existing site and survey data beyond that available strictly in the GIS records maintained by the SHPO. The data used for the large-scale production of the Class I Overview, completed as part of the PEIS, did not evaluate paper records of backlogged data or recent submittals that had not yet been entered digitally. Existing data, reviewed in this PEIS, do serve to provide a sample of the main types of sites that occur in the study area.

TABLE 3.9.5-2 Eligibility Status of Known Archaeological Sites in the 11 Special Tar Sand Areas, Utah

	Number of Sites in Each STSA											
Eligibility Status	Argyle Canyon	Asphalt Ridge	Circle Cliffs	Hill Creek	P.R. Spring	Pariette	Raven Ridge	San Rafael Swell	Sunnyside	Tar Sand Triangle	White Canyon	Total Number of Sites
Listed/Nominated	0	0	0	1	2	0	0	1	18	1	0	23
Eligible/NR Quality	0	8	49	142	45	53	6	8	299	61	0	271
Not eligible	1	18	58	356	91	71	19	10	43	77	0	744
Eligibility undetermined	0	1	9	6	15	1	4	1	49	7	1	94
Data not available	0	5	63	96	217	87	3	73	388	105	18	1,055
Total number of sites	1	32	179	601	370	212	32	93	797	251	19	2,587

is difficult, if not impossible, to place boundaries on locations of traditional significance. Where boundaries could be defined, tribal members may not be willing to disclose locational information for a variety of reasons. Cultural sensitivity to the need to protect culturally important resources is required during consultation. Types of valued traditional resources may include, but are not limited to, archaeological sites, burial sites, traditional harvest areas, trails, certain prominent geological features that may have spiritual significance (i.e., sacred landscapes), and viewsheds from sacred or culturally important locations (including all of the above). An ethnographic overview for the areas considered for leasing in this PEIS has recently been prepared that provides a general description of the lifeways and traditional property types of Native Americans who either currently live or previously lived in the region covered by this PEIS (Bengston 2007). In addition, federally recognized tribes with current or historic ties to the area have been contacted. Information from ethnographic overview has been summarized and updated in Sections 3.10.1, 3.10.2, and 3.10.3, along with general information provided by the tribes. Exact locations of sacred and culturally important sites are confidential and are not provided here.

3.10.1 Piceance Basin

The Piceance Basin lies within the traditional range of Numic-speaking tribes. The Ute Indians came to dominate what is now western Colorado, but the Eastern Shoshone were also present in northwestern Colorado (Baker et al. 2007). Ute oral tradition indicates an extensive presence of Ute people in Colorado and Utah and northwestern New Mexico since at least the sixteenth century. The Utes organized and identified themselves according to band membership. This membership appears to have been fairly fluid and interchangeable (Ott 2010). Approximately nine different Ute bands are thought to have inhabited the three-state study area (Bengston 2007). The area was likely used by all of the Ute bands at one time or another for hunting, gathering, trading, or socializing. Seasonal migrations of Ute families involved traveling to deserts and valleys in the winter and up into the mountains in summer to meet their subsistence needs. Ute families relied on hunting, particularly of big game, and the gathering of a wide variety of plant foods for subsistence. Families would come together at certain times of the year for communal hunting, ceremonial dances, or other social activities. Campsites or seasonal village sites often included tipis borrowed from their plains neighbors, as well as conical wooden and brush shelters called wickiups (Martin et al. 2005). The introduction of the horse allowed the Utes to venture more widely and to hunt buffalo on the plains.

The Shoshone way of life was similar to that of the Utes. They practiced a seasonal round of hunting and gathering, coming together to winter in the Wind and Green River Valleys, then dispersing widely, to places likely including the Piceance basin, and coming together again to venture on to the plains to hunt bison. By the mid-18th century they had adopted the horse (Shimkin 1986a), raiding the plains with their Comanche allies (Shimkin 1986b). Initially operating as independent family hunter gatherers and later as trappers for the fur trade, by the mid-19th century pressure from plains tribes retreating from westward American expansion led the Shoshone to coalese into a self-aware tribal unit under Chief Washakie. On their seasonal round they constructed wooden shelters similar to Ute wickiups. Today, the Eastern Shoshone share the Wind River Reservation in Wyoming with the Arapahoe, former enemies.

Today, Ute bands are organized into four distinct tribal entities, located primarily on three reservations. The Ute Indian Tribe occupies the Uintah and Ouray Reservation in eastern Utah. The Southern Ute Tribe lives on the Southern Ute Reservation, and the Ute Mountain Ute Tribe lives on the Ute Mountain Ute Indian Reservation, both in western Colorado. The White Mesa Band of the Ute Mountain Ute Tribe, located in southeastern Utah, is a semiautonomous entity that is part of the Ute Mountain Ute Tribe. Of these the Ute Indian Tribe is closest to the Piceance Basin; however, since Ute band membership was fluid, potentially all modern Ute tribes could have historic ties to the basin. The BLM has reached out to all four Ute tribal entities seeking input regarding the development of oil shale and tar sands. The three Ute tribes have expressed concerns over the effects of development upon the remains of wickiup sites in their traditional Colorado homeland. As discussed in Section 3.10.5, the BLM has met with the three tribes and conducted field visits to wickiup sites with tribal cultural authorities.

Traditional cultural properties are not distinguished in the site data files of the Colorado SHPO. Their significance must be defined from the point of view of the culture with which they are associated. While some archaeological sites or rock art panels listed in the database may be considered traditional cultural properties by the tribes, a traditional cultural property need not include anthropogenic materials. In the words of Betsy Chapoose of the Uintah and Ouray Reservation, “the Utes consider the air, the water, the view, all those things, the whole environment, as cultural resources” (Ott 2010). The presence of traditional cultural properties may be based more on specific geographic features. Culturally important places or landscapes could include religious sites associated with oral traditions and stories; traditional gathering areas; quarries; trails; offering areas; game drives; eagle traps; culturally scarred trees; and other use sites. They may also include constructed features including cairns, wickiups, brush fences, tree platforms, altars and shrines; vision quest group ceremonial sites, such as sweat lodges and ceremonial dance grounds; ancestral habitation and camp sites; burials and reburials; and observatories and calendar sites (Bengston 2007; Ott 2010). Identification of these resources occurs through government-to-government consultation with the contacted federally recognized tribes and a careful and thorough ethnographic and ethnohistoric assessment (e.g., Bengston 2007).

A recent evaluation of wickiup sites in the Yellow Creek area of Rio Blanco County has determined that while most sites were likely Ute sites, some may have been constructed by the Shoshone. The material culture of the two groups is so similar that the builders of the sites could not be distinguished based on material remains alone (Martin and Miller 2009a,b). Some could date back to the end of the 18th century, before the Utes came to dominate this part of Colorado (Martin et al. 2010). Tribal authorities from the Ute tribes have requested that Eastern Shoshone be included along the Utes when evaluating wickiup sites in the Piceance Basin (Ott 2010). The Eastern Shoshone were invited by the BLM to participate in field trips to wickiup sites in Rio Blanco County; however, a tribal representative was unable to attend.

3.10.2 Uinta Basin

The Unita Basin is located in Utah due west of the Piceance Basin. It is likewise within the traditional range of the Utes. The ethnohistoric context presented in Section 3.10.1 is therefore also applicable to the Uinta Basin. The Ute Indian Tribe of the Uintah and Ouray Reservation has identified an area of tribal lands south of the Grand County–Uintah County border as pristine wilderness that included sacred hunting grounds (Loosle 2012). The tribe has placed this area off limits to all mineral exploration. However, the tribe has expressed some interest in development of oil shale and tar sands resources on split estate reservation lands within the Hill Creek Extension of the Uintah and Ouray Reservation where the tribe owns the surface. The tribe requests that they be consulted prior to offering leases for any split estate parcel on reservation lands (Natchees 2007).

Traditional cultural properties are not indicated as such in the site data files of the Utah SHPO; however, in some cases the possible cultural affiliation of a site is presented as part of the prehistoric-historic site categorization. Some archaeological sites recorded in the database may be considered traditional cultural properties by the tribes. As discussed in Section 3.10.1, traditional cultural properties include more than archaeological sites. Identification of these places occurs through government-to-government consultation with the contacted federally recognized tribes and a careful and thorough ethnographic and ethnohistoric assessment. Several previous ethnographic overviews have been completed for this region in Utah (Bengston 2007).

3.10.3 Green River and Washakie Basins

The Green River and Washakie Basins lie predominantly within the traditional range of the Eastern Shoshone, although the Utes may also have occasionally exploited the area (Bengston 2007). Eastern Shoshone territory covered most of present-day western Wyoming and parts of northeastern Utah and northwestern Colorado. An even larger range of land was used for hunting buffalo. The Eastern Shoshone generally wintered along the Green River (Bengston 2007). The Eastern Shoshones tended to form larger, highly militaristic groups or bands (Shimkin 1986b). This was likely because of their greater dependence on the buffalo and the more frequent occurrence of warfare with the other Plains tribes. However, membership in the various bands was fluid and changeable as with other Shoshone bands (Bengston 2007; Shimkin 1947, 1986b).

The lifeways of the Shoshone bands varied according to their environment and whether or not they had horses. The bands that depended on horse and buffalo hunting, like their Plains counterparts, generally lived in Plains-style tepees. Their subsistence lifeways depended more on hunting and fishing than on plant gathering. Those bands living near major rivers subsisted primarily on salmon and other fish. The Eastern Shoshone depended mostly on faunal resources supplemented with berries, roots, seeds, and wild greens (Shimkin 1986b; Bengston 2007).

The Ute heartland lies in southeastern Colorado; however, by the mid-1600s the Utes had acquired horses and had migrated into northern Colorado and Utah and, according to Ute oral tradition, possibly southwestern Wyoming. The Utes also moved eastward into the Great Plains and adopted a plains lifestyle of buffalo hunting and living in tepees. Northern Arapaho also may have made use of lands in the study area, but there is less documented evidence of this. The Northern Arapaho territory expanded into eastern and northern Wyoming and Kansas from eastern North Dakota and Minnesota after the Arapahos began using horses in the early 1700s.

The Arapahos specialized in big game hunting and supplemented their diet with roots, berries, fruits, nuts, and tubers (Bengston 2007).

The Northern Arapaho and Northwestern Band of the Shoshone Nation did not choose to consult regarding the present project. The Eastern Shoshone expressed an initial interest in participating as a cooperating agency and were sent an MOU to enable that. However, they chose not to sign and return the MOU. Attempts by the BLM to schedule a meeting with the Eastern Shoshone Business Council were not successful. Earlier, the Eastern Shoshone and Northern Arapaho met with the BLM during the preparation of the 2008 PEIS. While one tribal representative expressed the view that all land is sacred, most of the discussion centered on how cultural resources would be identified and assessed during lease sales and the process for providing information on tribal concerns to the BLM. No specific resources of concern were identified. The Northwestern Band of the Shoshone Nation communicated that the tribe had interest in certain areas that might be affected by the proposed action, but did not identify the areas.

Traditional cultural properties are not indicated in the site data files of the WYCRO. Although some archaeological sites recorded in the WYCRO database may be considered traditional cultural properties by the tribes, such as some of the burials, cairns, rock alignments, and rock art sites, as discussed Section 3.10.1, many traditional cultural properties and other resources important to tribes may not contain archaeological materials. Identification of these resources occurs through government-to-government consultation with the relevant federally recognized tribes and a careful and thorough ethnographic and ethnohistoric assessment. An ethnohistoric overview of the area was conducted in 2007 (Bengston 2007). To date, no specific properties have been identified (Bengston 2007).

3.10.4 Special Tar Sands Areas in East-Central and Southeastern Utah

The STSAs are scattered across the traditional ranges of the Utes and Paiutes and in areas of interest to the Navajo and Puebloan tribes. The ethnohistoric context presented in Section 3.10.1 is applicable for several of the STSAs within or adjacent to the Uinta Basin. As discussed in Section 3.10.2, the Ute Indian Tribe has expressed some interest in development of oil shale and tar sands resources on split estate tribal lands within the Hill Creek Extension of the Uintah and Ouray Reservation. More southerly STSAs are located in areas of possible interest to Paiute, Navajo, and Puebloan tribes. Southern Paiute bands ranged at least as far east as the Colorado River (Kelly and Fowler 1986). Numic speakers like their Ute neighbors, they lived in highly mobile bands, hunting, gathering, and farming following a seasonal round. They favored semipermanent campsites at the bases of scarps or lower slopes, near water sources and juniper stands. The traditional Southern Paiute bands closest to the STSAs were the Paguitch, Kaparowits, and Antarianunts. Today’s Kaibab Band includes descendants of these groups, as do Paiute Bands living farther west (Bengston 2007).

Archaeological evidence suggests that the Athapaskan-speaking Navajo are relative newcomers to the area. While the Navajo Reservation extends into southeastern Utah, there is little documented evidence of Navajo occupation of the tar sands study area, although Navajo burials have been reported as far north as Monticello, Utah. Modern Puebloan tribes such as the Hopi, Zuni, and the Tewa speakers claim cultural affiliation with Fremont, Archaic, and Paleoindian archaeological cultures, seeing them as their ancestors (see Section 3.9) (Bengston 2007). In contacts made during the preparation of the 2008 PEIS, the Hopi expressed interest in eastern Utah as far north as Price. The Pueblos of Laguna, Nambe, and Zia in New Mexico, while identifying no resources of current interest, requested that they be notified if archaeological or human remains were encountered during surveys and development.

Traditional cultural properties are not indicated as such in the site data files of the Utah SHPO; however, in some cases the possible cultural affiliation of a site is presented as part of the prehistoric-historic site categorization. Some archaeological sites recorded in the database may be considered traditional cultural properties by the tribes. As discussed in Section 3.10.1, traditional cultural properties and other resources important to tribes include more than archaeological sites. The Paiute Indian Tribe of Utah included culturally important plants, animals, springs, and other places of cultural significance (Martineau 2006). Both the Kaibab Band of Paiute Indians and the Navajo Nation identified the Henry Mountains, located between the Circle Cliffs and Tar Sand Triangle STSAs, as sacred. Identification of these resources occurs through government-to-government consultation with the contacted federally recognized tribes and a careful and thorough ethnographic and ethnohistoric assessment. Several previous ethnographic overviews have been completed for this region in Utah (Bengston 2007).

3.10.5 Summary of Tribal Consultation

The BLM developed a process to offer specific consultation opportunities to "directly and substantially affected" tribal entities, as required under the provisions of E.O. 13175, and to Indian tribes as defined under 36 CFR 800.2(c)(2). Starting in July 2011, 25 federally recognized tribes that are located in or that have historical or cultural ties to the three-state study area were contacted by mail by the three BLM State Directors. These letters provided notification of the BLM's intention to take a fresh look at land use allocation decisions regarding the management of oil shale and tar sands resources made in 2008. The BLM has followed up with additional letters, e-mails, telephone calls to, and meetings with tribes who have expressed a wish to continue government-to-government consultation. Table 7.2 1 lists by state the tribes that were contacted and describes the status of the ongoing consultations with each tribe. Once the Draft PEIS was completed (BLM 2012b), a second mailing was sent to all federally recognized tribes with interests in the area under consideration. Follow-up meetings, discussions, and field visits to potentially important resources took place after the Draft PEIS was issued. Two tribes (the Hopi and Eastern Shoshone) expressed an initial interest in consultation or involvement with the BLM for this project, and one Navajo Chapter (Navajo Mountain) requested additional information. The BLM followed up with all three tribes, providing information about the project. Two tribes (the Pueblo of Santa Clara and the Paiute Indian Tribe of Utah) have indicated that further consultation is not needed. The remaining 10 tribes (Kaibab Paiute Tribe, Northern Arapaho Tribe, Northwestern Band of the Shoshone Nation, Pueblo of Laguna, Pueblo of Nambe, Pueblo of Zia, Pueblo of Zuni, San Juan Southern Paiute Tribe, Shoshone-Bannock Tribes, and White Mesa Band of the Ute Mountain Ute Tribe) and 7 Navajo chapters (Aneth, Dennehotso, Mexican Water, Oljato, Red Mesa, Teec Nos Pos, and Window Rock) have yet to respond to the BLM's request for consultation.

On March 21, 2012, the BLM held a consultation meeting with the Tribal Historic Preservation Officer and cultural representative of the Ute Mountain Ute Tribe to discuss the Colorado portion of the project area. They expressed concerns with the protection of wickiup sites and the cultural landscape under all alternatives. Particular tribal concerns were identified with the Yellow Creek area in Rio Blanco County, Colorado. They could not place a physical boundary around the cultural landscape without seeing the area and wanted input from the cultural representatives of the Southern Ute Indian Tribe, the Ute Indian Tribe of the Uintah & Ouray Reservation, and the Eastern Shoshone Tribe in defining this boundary. A face-to-face consultation meeting was requested with the aforementioned tribes to include a site visit to wickiup sites in the Yellow Creek area.

The BLM set up a site visit and consultation meeting on May 2, 2012, in Meeker, Colorado. Only Betsy Chapoose, the cultural representative from the Ute Indian Tribe of the Uintah & Ouray Reservation, was able to participate. Clifford Duncan, a traditional elder from the Ute Indian Tribe of the Uintah & Ouray Reservation, visited the area on May 24, 2012. Separate site visits and consultation meetings were held on June 6, 2012, and August 1, 2012, for cultural representatives of the Southern Ute Indian Tribe and the Ute Mountain Ute Indian Tribe, respectively. The Tribal Historic Preservation Officer for the Eastern Shoshone Tribe was invited to all the meetings but was unable to participate.

The purpose of the site visits and consultation meetings was to view the landscape of the overall area, to inspect a few representative examples of wickiup sites, to discuss the appropriate means of protection for these sites, and to identify a protection boundary around them. The BLM's intent is to work with the tribes to assure that land management activities consider and protect places of traditional religious and cultural importance.

The wickiup sites and the surrounding cultural landscape have traditional religious and cultural importance to the three Ute tribes and the Eastern Shoshone Tribe. Betsy Chapoose stated that their significance must be defined from the point of view of the culture with which they are associated, "the Utes consider the air, the water, the view, all of those things, the whole environment, as cultural resources" (Ott 2010). All of the Ute cultural authorities visiting wickiup sites in Colorado suggested that the sites need to be seen as part of a larger landscape that includes topography and associated plant and animal communities that would have provided traditional resources. They reflect the indigenous culture.

The consultations indicated that wickiup sites were temporary in use, primarily for hunting and for seeking refuge from military authorities for anywhere from a few days to as long as a month. Some structures may have served as menstrual huts. The structures were left standing and were reused. The structures were used to protect the inhabitants from bad and cold weather; temporary brush structures were used at other times. Brush fences are a resource of interest because of their association with moving wildlife during hunting.

The protection of the wickiup sites was described in various ways. One needs to look at the landscape, and not just a circle around a site. All agreed that an avoidance area is needed around each site. They recommended distances ranging from 100 ft to 500 m, and another recommended no preferred distance. One suggestion was to avoid the site, so that the development was not visible from the site. All of the tribes agreed that where a concentration of wickiup structures exists as a village, a protection buffer around the village be established. These authorities would like to have these aboveground structures preserved from harm by development, but destruction by natural phenomena such as lightning was natural and not objectionable. Long-term reclamation of the development projects was also mentioned as a possible mitigation measure.

The Ute Indian Tribe of the Uintah and Ouray Reservation also expressed concerns regarding developments that would directly affect their reservation in the Uinta Basin (Natchees 2007). The Ute Indian Tribe also discussed the leasing of split estate lands on their reservation. Interaction with the Ute Indian Tribe is ongoing.

The concerns raised during consultation during the development of the PEIS will be incorporated into any future leasing discussions. No specific leasing actions are part of the current action and therefore none of the resources or issues identified by the tribes will be affected by the current action. As described in Section 3.9, future consultation would occur when a specific lease is proposed under the program. Additional inventory and studies would be undertaken on any proposed lease area in order to take cultural landscapes, wickiups, and other issues raised by the tribes into consideration before a lease would be granted.

The BLM will continue to provide consultation opportunities for interested tribes and will continue to keep all tribal entities informed about the NEPA process for the PEIS. In addition, the BLM will continue to implement government-to-government consultation on a case-by-case basis for site-specific oil shale and tar sands resource development projects. (See Appendix L for copies of the correspondence.)

3.11 SOCIOECONOMICS

3.11.1 Past Oil Shale Development

Although small quantities of oil shale were produced between 1915 and 1925, with additional exploration activities occurring in the 1950s, major attempts to develop oil shale resources did not occur until the early 1970s with the imposition of the Middle East oil embargo and the resultant attempt to reduce U.S. dependence on foreign oil supplies. The federal prototype leasing program begun in 1974 attracted bids from a number of companies. The Blanco Oil Shale Project on Yellow Creek south of Rangely in Colorado was started by Gulf Oil on tract C-a with the aim of producing 50,000 bbl/day by 1987, while TOSCO and Atlantic Richfield leased land on tract C-b, with both projects planning to use in situ processing to produce 57,000 bbl/day by 1982 (Lamm and McCarthy 1982). Sites U-a and U-b in Utah were also leased at this time by Sun Oil and Phillips Petroleum. In addition to planned developments on federal land, during this period, oil companies also bought land holdings on private land, with 14 companies purchasing land in the Piceance Basin by 1979. The largest development on private land was the Colony Project, begun by Atlantic Richfield, Shell, Ashland, Cleveland Cliffs, and TOSCO in the early 1970s. Using room-and-pillar mining and surface retorting, the project extended from Parachute Creek to the Roan Plateau and produced 800 bbl/day by 1972, with 50,000 bbl/day planned by 1985. The Paraho Development Company also established a project using surface retorting in the U.S. Naval Oil Shale Reserve west of Rifle (Lamm and McCarthy 1982).

Despite the financial commitment by private companies, and the willingness of the federal government to lease lands for oil shale development, none of the projects begun in the 1970s were successful, and by 1976 a number of companies had withdrawn from the federal leasing program. Despite inflation in world oil markets following the 1973 Organization of Petroleum Exporting Countries (OPEC) oil embargo, no major technological breakthrough had been made to make oil shale viable on a commercial scale. In addition to economic and technological considerations, significant unresolved legal difficulties had emerged over title disputes, unpatented mining claims, and disputes over Ute Indian land claims (Lamm and McCarthy 1982). By the early 1980s, following the 1980 oil embargo, the political and economic environment for the development of synthetic fuels changed dramatically. The passing of the Energy Security Act of 1980 was intended to decrease U.S. dependency on foreign oil, and included a 5-year $19 billion program of incentives to encourage private industry to build synfuel plants in order to produce 500,000 bbl/day by 1987, and 1 million bbl/day by 1992. Although the Act provided massive incentives for development and significantly reduced the risks of development for private companies, the plan did not receive widespread political support in the western states, with concerns over states' rights, ethical questions surrounding support for energy companies, water rights, environmental laws regarding strip mining, water and air pollution, and historic preservation (Lamm and McCarthy 1982).

In spite of serious doubts from western politicians, various companies, including TOSCO, which had previously invested in the Colony Project with Exxon, received loan guarantees from the federal government, and numerous subsidy applications were made by other companies. As a result of the Energy Security Act, several new projects were started in Colorado, including the Chevron Clear Creek project, which planned to produce 100,000 bbl/day by 1994, and the Mobil project, which aimed for 100,000 bbl/day (Lamm and McCarthy 1982). In Utah, Chevron began a processing plant near Farmington; TOSCO planned a 48,000-bbl/day plant at Sand Wash in the northeastern part of the state, while Paraho announced a project to be started near Vernal in 1982. The largest development, however, was the Colony Project announced by Exxon in 1980, which envisaged production of 47,000 bbl/day, to be built without the help of federal subsidies (Rasmussen 2008). In anticipation of continued increases in world oil prices, Exxon advocated the large-scale development of the U.S. synthetic fuel industry and produced highly optimistic projections of the role of the oil shale in domestic oil production, suggesting that up to 600,000 bbl/day could be produced by 1990, 1 million bbl/day by 1995, and 8 million bbl/day by 2010, involving the development of 80 plants in Garfield and Rio Blanco Counties. Despite the absence of a commercially viable processing technology, the company projected the development of 150 oil shale plants over a 20-year period, with six massive strip mines, each 3.5 mi long, 1.75 mi wide, and 0.5 mi deep. Each mine would require 22,000 workers, with 8,000 workers at each processing plant (Gulliford 1989).

To accommodate the workforce required to produce 1 million bbl/day, Exxon began construction of a new community at Battlement Mesa, which would double the population of

Garfield County. It was estimated that 700 schools, 3,000 teachers and staff, 700 police officers and firemen, and 200 doctors would be required (Gulliford 1989). Population in the Colorado River Valley would grow to 1.5 million, with 75,000 new housing units required to accommodate the new workforce. It was suggested that 7,000 ac-ft/yr of water would be needed for one 50,000-bbl/day plant, with 350 ac-ft/yr needed for every additional 1,000 population. Although Exxon had water rights on water from the Colorado River, with additional supplies available from the Ruedi Reservoir (Rasmussen 2008), oil shale production of 4 million bbl/day would require almost 870,000 ac-ft/yr (Gulliford 1989). To satisfy water demand for the larger development, Exxon envisioned a pipeline from the Missouri River in South Dakota, with interbasin transfers thought to be possible with sufficient state and federal political will. Three 1,000-MW power plants were also to be built to provide the energy to pump the water through the pipeline into western Colorado.

Even before the Colony Project started in 1980, there had been significant property speculation in communities associated with oil shale development, and rapid inflation in property values was experienced in many communities. In Rifle, for example, lots selling for $12,000 in 1974 sold for $115,000 in 1979 (Gulliford 1989). Land parcels were often bought and sold two or three times a year as business in oil shale communities grew. Building permits worth a total of $500,000 were granted in 1976; by 1980, permits totaled $14 million. Often land was sold to speculators who were from outside the area and were not necessarily interested in the long-term well-being of the community. There was also rapid expansion in retail sales and retail prices, which led to considerable turnover in local small businesses, with local business owners also often from outside local oil shale communities (Gulliford 1989).

According to reports in the *Rifle Tribune*, a local newspaper established at the beginning of the oil shale boom, oil shale development affected many aspects of community economic and social life, even before the Colony Project, with the delicate social fabric of community and neighborliness that had evolved over generations overwhelmed by large-scale in-migration of transients from a wide range of communities outside the oil shale region, many of whom, it was perceived, had no intention of working (Gulliford 1989). Personal relationships typical of rural social life were quickly replaced by impersonal relationships based primarily on marketplace relations (see Section 3.11.2.2.5). The boom was particularly threatening to people on fixed incomes, with rapid increases in rents, grocery bills, and other expenses. Massive increases in drug and alcohol abuse, and domestic violence were also reported, with corresponding increases in caseload for social and mental health workers. Rapid increases in poaching of elk and deer were reported, in addition to increases in off-road traffic, and little desire to buy homes. Local retailers moved quickly to supply in-migrant workers with cars, trucks, snowmobiles, boats, and a range of other smaller items, replacing goods traditionally purchased in small ranching communities. In addition to in-migrants searching for oil shale employment, there was also a large influx of professional workers looking for employment in growing oil shale community economies, resulting in considerable improvement in the availability and quality of local services. Oil shale towns were often professionally managed with sophisticated zoning and planning procedures (Gulliford 1989).

To address the emerging housing crisis, Union Oil built employee housing to the north of Parachute, with modular housing on 380 acres for 1,000 workers (Gulliford 1989). Although the employer-provided housing succeeded in keeping single, male construction workers isolated from the local community, the housing did not address the problem of low-income workers arriving without jobs, and living in campsites or in their cars. Expenses involved in evicting squatters in Garfield County led quickly to requests that Union Oil pay some of the costs associated with rapid population growth. By the time the Exxon Colony Project began, there were various stipulations included in the permit, including guaranteed housing for 80% of project workers, local road upgrades, prepayment for all water and sewer hookups and waste disposal, provision of worker transportation, and annual socioeconomic monitoring reports. The company also contributed to local education capital spending, and provided support for local fire, police, and emergency management services. Exxon also started construction on a purpose-built community at Battlement Mesa to house 25,000 people, which was to include 7,000 house and trailer spaces, a 100,000-ft^2 shopping center, office buildings, a park, an indoor recreation facility, schools, churches, and a golf course (Gulliford 1989).

By early 1982, the Colony Project workforce had reached 2,100 and, in order to process up to 50,000 bbl/day, was projected to reach 6,992 by 1985 (Gulliford 1989). Rather than continue rapid development, however, in May 1982, Exxon decided to close the Colony Project, leaving thousands of oil shale and support workers unemployed. Within a week, an estimated 1,000 people had left Parachute and Garfield County. There were sharp changes in community expectations about growth, employment, and lifestyle, and social relationships and family ties changed radically. High-priced, former ranching land was sold back to previous owners at low prices, but was still subject to high taxes. Some farmland and drainage had been damaged by development and could not be recovered. The housing market immediately deflated with many houses for sale, and local contracts and orders for materials and supplies were cancelled. High rents for new apartment buildings in Battlement Mesa could not be recovered, thus impacting rental markets elsewhere in the region. Restaurants lost business, and office and retail space went vacant. For some time after closure, transient workers continued to arrive in Parachute, remaining a problem for the local community, which impacted social and educational services. Churches closed or had to radically reduce their obligations to their congregations. Social services and other government departments suffered severe cutbacks and employee layoffs. Many local government departments were left with buildings and infrastructure that were too large for the remaining population, making them expensive to operate and impacting local tax rates. Although Battlement Mesa was later successfully marketed as a retirement community, to many the development represented 3,000 acres of sprawl, while Parachute was left with many older buildings in need of repair (Gulliford 1989).

The bust period lasted for multiple years after the initial announcement. Population in Mesa County fell from 94,000 in 1980 to 83,000 in 1985. Eighty-five million dollars in annual payroll was lost. Numerous businesses had been started throughout the region, and retail and transportation facilities had been built with the expectation of population and economic growth. Bankruptcies and housing foreclosures were commonplace; 200 businesses in Rifle alone had failed 18 months after the project closed, while foreclosures in Mesa County rose from 98 in 1981 to 1,042 in 1984 (Gulliford 1989). Occupancy rates in Battlement Mesa were at 35% in 1984. The closure of the Colony Project affected the entire western Colorado region; by 1984, unemployment levels had reached 9.5%, and by 1985, 14.2% of all housing in Grand Junction was vacant. It became apparent that preboom conditions would not return to the economy in many respects. Many businesses that had operated for generations had failed and would not be reopened. Together with the decline in the coal and the oil and gas industries, the value of farm produce, and consequently ranching land, also declined. A survey identified 7,400 people that would leave in 1984, with losses in population from 1981 to 1984 representing 15 years of population growth in Mesa County. Foreclosures in Mesa County reached 1,600 by 1985. Garfield County had lost 6,472 jobs and 3,745 residents between 1981 and 1985 (Gulliford 1989).

The psychological impacts of the bust on the local community, in particular its suddenness, although not well-documented, may have been significant (see Section 3.11.2.2.5), with many financial and family decisions hinging on rapidly rising incomes and changing community social structures (Gulliford 1989). Although Exxon had promised an orderly closure, plant workers were not given advance notice. Many workers had expected to be in the area for many years and had borrowed money, purchased houses and other expensive items, moved their families into the local community, and placed their children in local schools. Individuals and institutions had trusted Exxon, had seen the size of the capital initially invested in the project and had assumed that progress on the project would continue. Even after closure of the project, many businesses remained open, and immediate population decline was not severe. Many long-term residents and those in-migrants that remained after closure preferred not to believe that economic collapse was possible, and instead hoped for a government buyout of oil shale infrastructure, or that another major employer would move in (Gulliford 1989). Changes in social behavior also became apparent as a result of declining incomes, as people became isolated from their neighbors; communities began looking inwardly to help each other rather than to other communities in the Colorado River Valley. Divisions also developed between existing and new residents; while surviving social networks could be relied upon by older residents, newer residents had little informal community support, which produced alienation, family and marital problems, financial problems, domestic violence, drug and alcohol abuse, and divorce (Gulliford 1989) (see Section 3.11.2.2.5).

3.11.2 Current Conditions

The socioeconomic environment potentially affected by the development of oil shale and tar sands resources includes a region of influence (ROI) in each state (Colorado, Utah, and Wyoming), consisting of the counties and communities most likely impacted by development of oil shale and tar sands resources (Figure 3.11.2-1; Table 3.11.2-1). For each ROI, three key measures of economic development are described—employment, unemployment, and personal income. Five measures of social activity, population, housing, public service employment, and local government expenditures are also described. A number of measures of social well-being that may be affected by rapid population growth and “boom and bust” economic development—crime, alcoholism, drug use, divorce, and mental illness—are also described.

Because it is likely that the viewpoints, perceptions, and attitudes individuals may have toward large-scale energy development form an important background to current and future conditions in each ROI, a series of interviews was conducted with key stakeholders in Garfield and Rio Blanco Counties, Colorado, and Uintah County, Utah, to provide a context to the data

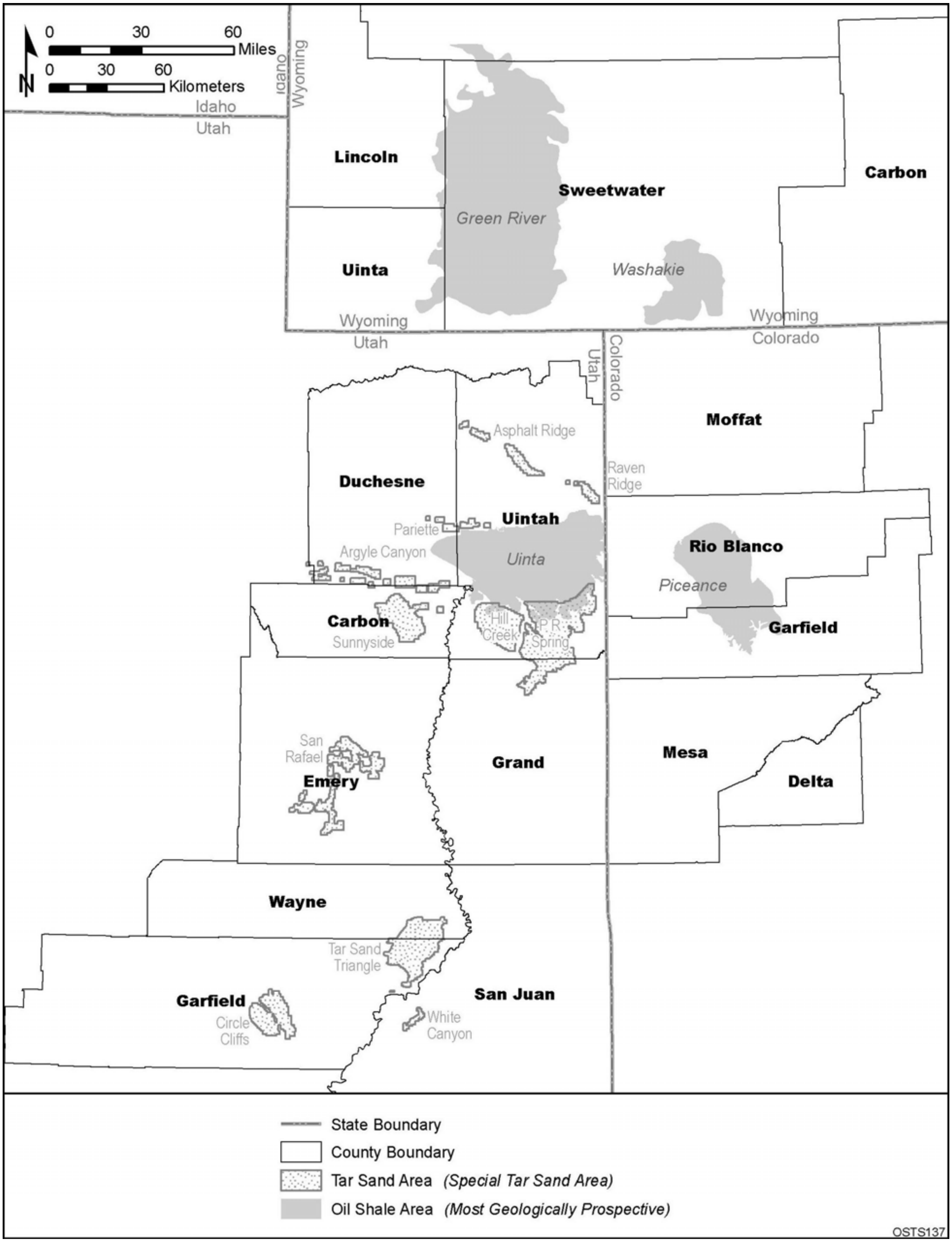

FIGURE 3.11.2-1 State ROIs for Oil Shale and Tar Sands Development Areas

TABLE 3.11.2-1 Jurisdictions Included in Each ROI

Colorado ROI	
Counties	Delta, Garfield, Mesa, Moffat, and Rio Blanco
Cities	Delta, Clifton, Craig, Fruita, Glenwood Springs, Grand Junction, Parachute, Meeker, Rangely, Rifle, and Silt
School districts	Craig, De Beque, Delta County, Roaring Fork (Glenwood Springs), Parachute, Plateau Valley (Colbran), Meeker, Mesa County Valley (Grand Junction), Moffat County, Rangely, and Rifle
Utah ROI	
Counties	Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, and Wayne
Cities	Moab, Price, Roosevelt, and Vernal
School districts	Carbon County, Duchesne County, Emery County, Garfield County, Grand County, San Juan County, Uintah County, and Wayne County
Wyoming ROI	
Counties	Carbon, Lincoln, Sweetwater, and Uinta
Cities	Evanston, Green River, Kemmerer, Rawlins, and Rock Springs
School districts	Afton, Evanston, Diamondville, Green River, Lyman, Mountain View, Rawlins, Rock Springs, and Saratoga

presented in the following sections. Individuals contacted were those who provided comments as part of the project scoping process, people who have been involved from the early stages of oil shale development, including local and county planning officials, community leaders, community service providers, realtors, and individuals located in proximity to project developments likely to be impacted by specific aspects of energy development. Participants were asked about past developments, particularly those that have produced “boom-and-bust” economic and social conditions that are deemed relevant, the current situation, including the ongoing impact of oil and gas and recreation, and the likely impact of new developments that might occur alongside developments in oil and gas and in recreation (see Appendix H). Each of the following sections presents a brief summary of concerns expressed during these interviews, as a means of providing a context for the economic and social data presented for each ROI.

In the following sections that report the opinions and perceptions of interview respondents, it should be noted that solicited information may or may not be consistent with statistics compiled by local, state, and federal agencies.

3.11.2.1 Economic Environment

3.11.2.1.1 Employment and Unemployment. Developments in the oil and gas industry have produced rapid growth in employment in many communities in each ROI, exacerbated by growth in recreation and in retirement communities in the Colorado ROI, meaning that there are significant labor shortages in numerous service industries, such as restaurants, car dealerships, and auto repair. Local government agencies are also experiencing staffing difficulties, where teaching, health, public safety, road and bridge, and fire personnel positions are currently difficult to fill. According to one Wyoming County planner, workers are recruited from as far away as Michigan.

Total employment in the Colorado ROI in 2010 stood at 126,351, 5.2% of all employment in the state (Table 3.11.2-2). Industries in the Utah ROI support 53,027 jobs, 4.2% of the state total, while the number of people employed in the Wyoming ROI, 47,041, represents 17.2% of total employment in the state. Employment in the Colorado and Utah ROIs grew relatively rapidly over the 2001 through 2010 period. Annual average growth in the Colorado ROI was 2.0% during this period, higher than the rate for the state as a whole (0.7%). Employment in the Utah ROI grew at a rate of 2.3% between 2001 and 2010, higher than growth in the state (1.5%) over the same period. At 0.4%, growth in the Wyoming ROI between 2001 and 2010 has been slower than in the other ROIs, with only a slightly higher average annual rate of 0.6% in the state.

Current unemployment rates are higher in each ROI (10.1% in Colorado, 8.7% in Utah, and 7.3% in Wyoming) than they were during the period 2001 through 2010 (Table 3.11.2-3). Rates for each of the ROIs were higher than those for the three states in 2010. With a relatively small labor force in each ROI, the number of local workers presently unemployed and potentially available for oil shale and tar sands developments is currently small. Statistics presented on unemployment rates may underestimate the number of people unemployed in each ROI, because the rates only include individuals available for work and currently collecting unemployment benefits.

TABLE 3.11.2-2 State and ROI Total Employment Data

Location	2001	2010	Annual Average Growth 2000–2010
Colorado			
ROI	106,079	126,351	2.0%
State	2,303,494	2,447,712	0.7%
Utah			
ROI	43,202	53,027	2.3%
State	1,108,547	1,262,083	1.5%
Wyoming			
ROI	45,345	47,041	0.4%
State	259,508	273,313	0.6%

Source: U.S. Department of Labor (2011).

TABLE 3.11.2-3 State and ROI Unemployment Data

Location	Average 2001–2010	Average 2010	Unemployed Persons (2010 Average)
Colorado			
ROI	3.7	10.1	14,257
State	3.8	8.9	217,846
Utah			
ROI	6.0	8.7	5,044
State	4.4	7.7	97,180
Wyoming			
ROI	4.0	7.3	3,703
State	3.9	7.0	19,132

Source: U.S. Department of Labor (2011).

3.11.2.1.2 Employment by Sector. Wage and salary employment in each ROI is dominated by employment in services and wholesale and retail trade (Table 3.11.2-4). Almost 65% of employment in the Colorado ROI is in these sectors (59,482 employed); more than 57% of employment in the Utah ROI (21,805) is in services and trade, with a slightly smaller number employed in these sectors in the Wyoming ROI (18,830, 53% of the total employed). The service and trade sectors are slightly more important in each state compared with each state ROI. The service sector includes employment in tourism and recreation, which has become an important part of the economy of the ROI in each state. Although the oil and gas sector constituted only a relatively small share of total ROI employment in 2004 (0.8% in Colorado, 2.9% in Utah, and 4.8% in Wyoming), the sector has seen significant growth in a number of counties in each ROI. In Colorado, oil and gas employment in Mesa County grew from 190 to 350 between 1998 and 2004, while employment in the sector in Garfield County in 2004 was 287, growing from 120 in 2002. In contrast, oil and gas employment in Rio Blanco County fell from 340 in 1998 to 120 in 2004. In Utah, oil and gas employment is concentrated in Duchesne County, with between 250 and 300 employed in the sector over the period 2000 to 2004, and in Uintah County, where employment grew steadily from 450 to 700 between 1998 and 2004. Each of the four ROI counties in Wyoming has oil and gas employment, with the largest concentrations in 2004 in Sweetwater (705 employees) and Uinta Counties (1,015), with fairly steady growth in both counties since 1998.

Employment in natural gas–producing counties in each of the three states has continued to grow since 2004 (see Section 6.1.1.10.1).

A number of industries are more important in the ROIs than at the state level, notably transportation and utilities in each state ROI (5.0% of total employment in the Colorado ROI, 9.0% of the Utah ROI, and 8.7% of the Wyoming ROI); agriculture in the Colorado ROI (5.0%) and Utah ROI (6.3% of the total); and mining in the Utah ROI (11.0%) and Wyoming ROI

TABLE 3.11.2-4 State and ROI Employment by Industry, 2009

Location	Agriculture[b]	Mining[a]			Construction	Manufacturing	Transportation and Utilities	Wholesale and Retail	Finance, Insurance, and Real Estate	Services	Other
		Oil and Gas	Coal	Total							
Colorado											
ROI	4,586	786	735	4,137	9,964	3,492	4,631	18,413	5,430	41,069	22
Percentage of total	5.0	0.8	0.9	4.5	10.8	3.8	5.0	20.0	5.9	44.7	0.0
State	40,307	8,980	2,052	25,127	141,420	121,919	68,716	344,429	142,253	1,159,997	325
Percentage of total	2.0	0.4	0.1	1.2	6.9	6.0	3.4	16.8	7.0	56.7	0.0
Utah											
ROI	2,388	1,220	1,500	4,167	3,732	1,494	3,414	7,083	1,494	14,722	10
Percentage of total	6.3	2.9	5.0	11.0	9.8	3.9	9.0	18.7	3.9	38.8	0.0
State	20,180	3,219	1,529	10,068	66,485	110,538	52,951	193,525	83,094	542,516	113
Percentage of total	1.9	0.3	0.2	0.9	6.2	10.2	4.9	17.9	7.7	50.3	0.0
Wyoming											
ROI	1,337	2,145	925	5,931	2,508	2,829	3,115	6,568	11,525	12,262	40
Percentage of total	3.8	4.8	3.0	16.7	7.0	7.9	8.7	18.4	4.3	34.4	0.1
State	10,082	13,046	4,829	24,682	19,751	10,453	12,329	40,386	11,569	95,165	124
Percentage of total	4.5	4.8	2.4	11.0	8.8	4.7	5.5	18.0	5.2	42.4	0.1

[a] Data for oil and gas employment and coal employment is for 2004; total mining employment data is for 2009. In addition to oil and gas extraction and coal mining, the mining total includes metals mining, nonmetallic minerals mining, and support activities for mining.

[b] Agricultural employment includes data for hired farm workers in 2007.

Sources: U.S. Census Bureau (2011a); USDA (2011).

(16.7%). The mining sector in each of the states includes the two sectors that would be directly impacted by oil shale and tar sands development—oil and gas extraction and coal mining. Coal mining has a slightly larger share of total employment in each ROI than other activities in the mining sector.

Employment in oil shale RD&D projects in Colorado and Utah has grown steadily since 1995, with an estimated workforce of 810 employed during construction and 535 during operations in the five current projects in Colorado, and with 120 employed during both construction and operation in the single current project in Utah. Indirect employment and income generated from these projects have also provided moderate additional benefits to the economy of each ROI (see Section 6.1.1.10.2).

3.11.2.1.3 Personal Income. In the Colorado and Utah ROIs, labor shortages in many nonenergy sectors and low unemployment rates described in Section 3.11.2.1.1 are partly due to an acute shortage of affordable housing (see Section 3.11.2.2.5), but they also occur because wages paid by oil and gas companies usually attract people from these occupations into a wide range of manual labor positions requiring little or no college education. Equipment operators, according to a Colorado assistant county manager, "can make 50% more" in the oil and gas sector than in local government agencies, "with wages of $26/hour, and despite an improved benefits package." Currently there are numerous vacant positions for these workers in Garfield and Rio Blanco Counties in Colorado. Industries in Utah and Wyoming unable to pay wages comparable to those in the oil and gas industry also suffer labor shortages. In Utah, according to a Uintah County planner, wages for clerical services occupations have almost doubled because of competition from the oil and gas industry, increasing from "$6 to $7/hr to $9 to $11/hr."

Labor incomes in oil and gas production were significantly higher than the average in each ROI. At $77,500, labor incomes in the sector in the Colorado ROI in 2004 were more than 70% higher than average incomes, and at $54,300 in Utah, 30% higher, while at $78,400, oil and gas labor incomes in Wyoming were slightly less than twice the average for all sectors in the ROI (U.S. Department of Commerce 2011). Labor incomes in oil and gas support activities were slightly higher than the ROI average in Colorado and lower than the ROI average in Utah, while labor incomes in oil and gas drilling were slightly lower than the ROI average in Colorado, and slightly higher than the average labor incomes in the Wyoming ROI.

Total personal income in 2009 stood at $9.1 billion in the Colorado ROI, $3.3 billion in the Utah ROI, and $4.1 billion in the Wyoming ROI (Table 3.11.2-5). Annual average growth in personal income over the period 2000 through 2009 was 3.3% in the Colorado ROI, 2.8% in the Utah ROI, and 4.3% in the Wyoming ROI. Per capita personal income grew from $32,776 in 2000 to $35,656 in 2009 in the Colorado ROI, from $23,426 to $29,813 in the Utah ROI over the same period, and from $33,851 to $43,161 in the Wyoming ROI (U.S. Department of Commerce 2011). State per capita income in each state in 2009 was slightly higher than each ROI.

Median household income in the Colorado ROI over the period 2006 to 2009 varied from $40,658 in Delta County to $64,837 in Garfield County (U.S. Department of Commerce 2011).

TABLE 3.11.2-5 State and ROI Personal Income

Location	$ billions 2010		Annual Average Growth, 2000–2009
	2000	2009	
Colorado			
ROI	6.8	9.1	3.3%
State	186.2	214.0	1.6%
Utah			
ROI	2.4	3.3	2.8%
State	69.7	89.4	0.3%
Wyoming			
ROI	3.0	4.1	4.3%
State	18.3	26.7	3.2%

Source: U.S. Department of Commerce (2011).

In the Utah ROI median incomes varied from $36,209 in San Juan County to $57,735 in Uintah County, and in the Wyoming ROI they varied from $50,963 in Carbon County to $67,210 in Sweetwater County.

3.11.2.2 Social Environment

3.11.2.2.1 Quality of Life. Although a relatively small number of individuals directly affected by the "boom and bust" associated with the Colony Project in the late 1970s and early 1980s remain in local communities in the vicinity of the project site, memories of the events before, during, and after the Colony development form an important part of the perception of large-scale energy development projects in western Colorado. The experience of the "boom and bust" and the long, slow recovery period in the 1980s and 1990s are both magnified and perpetuated, with many local government officers, city managers, and professional people currently residing in the affected communities also present during each phase of development. According to a Colorado city mayor, about "a third" of current residents in Rifle remember "Black Sunday," May 2, 1982, when "Exxon closed the gates to the Colony Project." Some local residents come from families that have lived in the area for many years, while many became residents during the oil shale boom, looking for work as teachers, local government officers, and realtors during the boom years prior to 1982.

Many people living in the area apparently still remember exactly what they were doing on Black Sunday, a date that is locally accorded the same significance as the date of the Kennedy assassination and the attack on the World Trade Center. More than 2,000 workers lost their jobs with the closure of the Colony Project, with many more out of work in the various supporting occupations in the economy of western Colorado, producing a "severe depression" throughout the region, according to a Colorado assistant county manager. Overnight, the housing market, which had struggled to keep pace with in-migration associated with the Colony development, with rapidly escalating prices for the few lower-priced homes that were available, collapsed. In the experience of one Colorado county manager, some properties lost "60% of their value in one week." Numerous recently constructed apartment buildings were left empty, many "businesses were lost," and banks closed, with "people standing in line to get their money," according to a Colorado assistant county manager, once the Federal Deposit Insurance Corporation had been called in. In Rifle, this signaled the beginning of a 10-year recession, with the economy of Garfield County not recovering until the mid-1990s.

Memories of the impact that the Colony Project had on economic and social life in the region are still vivid for people living in the area. The "huge workforce" of 2,000 required for the project meant a large and rapid influx of workers to staff construction vacancies and people looking for work in the associated boom. With the in-migrant population growing daily, the immediate problem associated with the project was an acute housing shortage, with, according to one Colorado city mayor, people "living in tents, under bridges and in culverts," while differences in the relative fortunes of the oil shale workers and the remainder of the working population in the local communities was clear, with the perception that in-migrant oil shale workers were "walking around with dollars dripping out of their pockets." The size and pace of oil shale development meant that community infrastructure also had to be expanded rapidly to accommodate the new workers and their families. In Parachute, the housing development built by Exxon at Battlement Mesa was "oversized" compared even to the housing demands of in-migrating oil shale workers, according to a Colorado county manager. The supporting infrastructure provided by local government (notably library, schools, roads, and sewers) was sized for a larger project than was required even at the time. Elsewhere in Garfield County, local planners had estimated infrastructure demands for the long term, with County Road 215 rebuilt to accommodate truck and car traffic for a large new development, while funding was also provided for additional public buildings.

While funding infrastructure developments to support the Colony Project put local jurisdictions under enormous financial pressure, with no severance tax revenues from oil shale production available during project construction, the additional infrastructure in Parachute and elsewhere in Garfield County, it is suggested, has provided a sound basis for the diversification of the area away from extractive energy and into recreation. With the Battlement Mesa development, together with smaller developments in the area and the associated public infrastructure, the Rifle area became "an affordable housing area for the entire region" according to a Colorado city mayor, with cheaper housing in the area eventually leading to population growth and recovery from the oil shale bust.

By the end of the 1990s, developments in the oil and gas industry in Colorado, Utah, and Wyoming had begun to place local communities under many of the same pressures they had experienced during the oil shale boom. Since 2003, the industry has created "a boom almost akin to oil shale," with "exponential growth" in population, large increases in the local working population, and higher employee income levels impacting community quality of life, according to a Colorado county manager. Many retail businesses, particularly grocery stores, have experienced problems maintaining sufficient stock to meet local demand. Beginning with the

Colony Project and continuing with current oil and gas development in both Colorado and Utah, patterns of retailing have changed from small, local general stores serving local retail demand, to the development of regional retail centers. Grand Junction, for example, which is 1.5 hours from Meeker, serves the region for most retail functions, with local stores limited to high-priced basic items, representing a "permanent change in life-style" that is perceived negatively by many local residents, according to a Colorado water commissioner. There is currently a single store in Meeker that sells feed, and people are prepared to drive 50 to 100 mi for large grocery purchases. Although Wal-Mart stores have been built in Rifle and Vernal, where a Lowe's has also been built, there is concern that these stores will have difficulties finding staff and will not be able to offer a range of goods at reasonable prices.

The lack of adequate transportation infrastructure has developed into a serious problem in Rio Blanco and Garfield Counties, with traffic levels on local roads particularly high during shift change times. Rapid development of oil and gas has meant that county authorities have had to "play catch up with traffic," according to a Colorado assistant county manager, with many local and county roads built only of gravel and not capable of supporting the necessary "12 to 18 80,000-lb" drilling rig and water tanker trucks required for oil and gas drilling activities. During the exploration phase, trucks are moved in and out of each well site "every 10 weeks" with older drilling technology, and "every 3 to 4 weeks" with newer production technology, according to the same county manager. At current employment levels, there are six people in each drilling crew, with three shifts for each rig. One worker is required for every six wells once production gets underway.

Lack of rail or interstate highway transportation infrastructure in Vernal, Utah, exacerbates the dependence on extractive industries, according to a Uintah County planner, with little opportunity for the town to develop as a retail hub. The additional infrastructure in Parachute and elsewhere in Garfield County on the other hand, it is suggested, has provided a sound basis for the diversification of the area away from extractive energy and into recreation.

To better plan for impacts of oil and gas development, various local and county citizen oversight groups have been formed in Colorado to provide for the communication of local community concerns to oil companies. Garfield County has established an Energy Advisory Board with representatives of oil companies and local citizens, and an Oil and Gas Liaison Committee that receives complaint calls and has attempted to reflect the concerns of the local community by undertaking local impact studies in a number of topical areas, notably water wells, health risk, air quality, and land values. Unfortunately, not all oil companies provide representatives for meetings, leaving one Colorado mayor "disgusted." In an attempt to develop a long-term coping strategy to address dependence on one major regional source of employment, Garfield County has identified a series of sectors to be targeted for development to allow economic diversification away from energy development. An "energy village" has been established to host renewable energy developments, including bio, solar, and possibly wind energy, and it has been proposed to make Rifle a regional commercial retail center. An additional impact of high local wages in the oil and gas sector is that it affects the ability of local communities to diversify, with teenagers able to drop out of school and earn "$60,000 to $70,000" in oil and gas jobs, leading to "a degradation in the college bound population," according to a Colorado county manager. With large labor transfers from nonenergy into energy occupations, the perception is that the oil and gas companies need only “warm bodies” to continue to operate.

Water allocation is a significant regional problem with the development of energy production in Garfield and Rio Blanco Counties, and the fact that energy companies have been buying historic water rights from ranchers is “a concern,” according to a city mayor in Colorado. Often ranchers are bought out by companies and nonlocal parties, and then the land with no associated water rights is leased back to the original owners with only limited water available for stock but not for irrigated agriculture. Many apparently perceive this as a “sad” development. Often hay is the only crop still being produced on many ranches, with only “nominal involvement in agriculture” on these properties “to avoid higher property taxes,” according to a Colorado water commissioner, with the perception that “there would be no agriculture in the area with commercial oil shale.” In the experience of a Utah city manager, the perception is that regional water capacity “can handle” population increases from oil and gas development.

Dramatic increases in traffic with the Colony Project and subsequent oil and gas development, often on roads into areas with very limited access, has often meant disruption to wildlife, in particular horse and elk herds. As a result, city government and many residents in Rifle oppose energy development on the Roan Plateau, not only because it interferes with a significant local source of income during the hunting season from September to November, but because the community in Rifle “is historically represented by hunting and fishing,” according to a Colorado city mayor. To avoid the steady disappearance of agriculture in the region with the purchasing of land for historic water rights in both Colorado and Wyoming, land has been sold for conservation easements, where historic water rights remain associated with specific land parcels. Although this provides a safe haven for game and preserves the land in more traditional uses, these easements “are not popular with out-of-state hunters,” who can no longer access game, according to a Colorado water commissioner. Conservation easements, particularly WSR designation, are also perceived as a threat to the traditional way of life in Utah, with the curtailment of vehicular access inhibiting hunters and anglers, according to a Duschesne County planner. Housing shortages also affect hunting, with insufficient local capacity during hunting months. Oil and gas workers are apparently excluded from some trailer park rentals, which are held exclusively for hunters. In Sweetwater County, Wyoming, in an attempt to preserve historic cultural heritage with the onset of energy development, “to understand why we live here,” land in the community of Adobetown was recently excluded from coal mining, according to a Sweetwater County planner.

Attitudes toward future energy developments vary from cautious optimism in the business community, “some of whom will benefit from new development,” according to a Colorado city mayor, to skepticism among those who remember the “boom and bust” associated with the Colony Project, the problems associated with housing migrant workers, the social impacts associated with temporary workers without their families, and the difficulties associated with planning public services and infrastructure. Many individuals are leery of oil shale development and do not believe that the technology is mature enough for commercial production; they are suspicious of new development given the history of the industry in the area. Some want tighter controls on development, especially housing, with infrastructure costs paid by developers. Even though Exxon received no subsidies from the federal government for the

Colony Project, some believe that the involvement of the Synfuel Corporation in the development of oil shale made it easier for oil companies to pull out, blaming the "boom and bust" on the end of federal subsidies. This perception stands in contrast to the current situation with oil and gas, where people apparently perceive that private companies receive no direct financial help from federal authorities. In Utah, although natural gas developments have been "immense," there is "stability compared to oil shale," according to a city manager, with people apparently sharing the view of the oil companies that there will be "long lasting and steady growth" in the area. Others were more skeptical, however. One Uintah County planner stated that oil and gas development was "scary to a lot of people," and wondered, "Are we setting ourselves up for another bust?" In Wyoming, one county commissioner was highly supportive of oil and gas development despite the drawbacks of infrastructure provision to support local population growth. The commissioner stated that the checkerboard pattern used by planning agencies for land use designation tended to drive oil and gas development onto private land, creating a "lack of balance," with unfair demands on infrastructure and public services in drilling areas.

3.11.2.2.2 Population. After a number of years of slow population growth, by the early 1990s, counties in western Colorado began experiencing higher growth rates. Driving the growth was the proximity of the area to the fast-growing winter recreation communities in Glenwood Springs, Aspen, and Vail, while Battlement Mesa itself has become a retirement community. Although commuting to these communities required a 70- to 90-mi drive, growth in these recreation communities, together with associated planning controls in these up-market communities, meant that there was little or no affordable housing for service workers in these resorts. As a result, Rifle and other communities in Garfield County have developed into "commuter towns," with "30,000 commuters" in the county predicted by 2025, according to a Colorado county manager. Over the past several years, population has grown rapidly in some communities hosting oil and gas developments, "at an annual rate of 4.9%, with rates of up to 7%" in Garfield County, according to a Colorado mayor. Local labor shortages have also led to an increase in the number of undocumented workers filling jobs in local service sector occupations, in the experience of a Colorado county manager.

In 2009, the population in the Colorado ROI stood at 254,227; the population in the Utah ROI was 112,037; and in the Wyoming ROI it was 94,868 (Table 3.11.2-6). The ROI population makes up a relatively small percentage of total population in Colorado (5.1%) and Utah (4.0%) and a larger percentage in Wyoming (17.4%). Population in the ROIs in each state grew relatively slowly over the 2000–2009 period. Annual average growth in the Colorado ROI was 2.3% during this period, higher than for the state as a whole (1.7%). In the Utah ROI, population grew at an average annual rate of 1.2% between 2000 and 2009, less than the state growth rate of 2.5% over the same period. At an annual rate of 0.9%, growth in the Wyoming ROI was slower than in the other ROIs, with only a slightly higher average annual rate of 1.1% in the state. Section 6.1.1.10.1 provides projections of population in each ROI for the years 2009, 2012, 2016, 2022, and 2027.

TABLE 3.11.2-6 State and ROI Population

Location	2000	2009	Annual Average Growth, 2000–2009
Colorado			
ROI	207,050	254,227	2.3%
State	4,301,261	5,024,748	1.7%
Utah			
ROI	101,019	112,037	1.2%
State	2,233,169	2,784,572	2.5%
Wyoming			
ROI	87,567	94,868	0.9%
State	493,782	544,270	1.1%

Sources: U.S. Census Bureau (2011c,d).

3.11.2.2.3 Urban Population and Income. The population of the Colorado ROI in 2009 was 57.3% urban; the largest city, Grand Junction, had an estimated population of 58,444; other larger cities in the ROI include Fruita (12,274), Craig (9,301), Rifle (9,255), Delta (9,253), Glenwood Springs (9,107), Carbondale (6,313), and New Castle (4,145) (Table 3.11.2-7). In addition, there are 22 smaller cities in the ROI with 2009 populations of less than 4,000.

Population growth rates in the Colorado ROI have varied over the 2000 to 2009 period (Table 3.11.2-7). New Castle grew at an annual rate of 8.5% during this period, with growth rates higher than the ROI average (2.3%) experienced in Fruita (7.4%), Silt (5.0%), Delta (4.2%), Grand Junction (3.7%), Rifle (3.5%), and Parachute (2.8%). The remaining cities experienced lower growth between 2000 and 2009, the majority experiencing growth rates of less than 2% during this period.

Median household incomes vary across cities in the Colorado ROI. Over the 2006 to 2009 period, Rifle ($72,824), Carbondale ($72,782), Redlands ($67,490), Silt ($66,300), Rangely ($60,560), De Beque ($59,431), and New Castle ($57,371) had median incomes that were higher than the state average ($57,144) (Table 3.11.2-7). More than 15% of individuals in seven cities—Dinosaur, Monte Vista, Parachute, Crawford, Del Norte, Delta and Clifton — were living in poverty over the period from 2005 to 2009.

The population of the Utah ROI in 2009 was 34.8% urban; the largest city, Vernal, had an estimated population of 9,225; other larger cities in the ROI include Price (8,236), Roosevelt (5,466), Moab (5,148), and Blanding (3,292) (Table 3.11.2-8). In addition, there are 50 smaller cities in the ROI with 2009 populations of less than 2,500.

Population growth rates in the Utah ROI have varied over the period 2000 to 2009 (Table 3.11.2-8). Naples grew at an annual rate of 3.4% during this period, with growth rates

TABLE 3.11.2-7 ROI Urban Population and Income for the Colorado ROI

City	Population			Median Household Income			Individuals Living in Poverty[a]
				$ 2010			
	2000	2009	Average Annual Growth Rate, 2000–2009	1999	2005–2009[a]	Average Annual Growth Rate, 1999 and 2005–2009	
Battlement Mesa	3,497	NA[b]	NA	46,448	51,265	1.1%	6.7%
Carbondale	5,196	6,313	2.2%	66,391	72,782	1.0%	10.6%
Cedaredge	1,854	2,272	2.3%	34,672	35,548	0.3%	10.1%
Clifton	17,345	NA	NA	40,121	43,073	0.8%	15.7%
Colbran	388	439	1.4%	41,155	43,985	0.7%	10.9%
Craig	9,189	9,301	0.1%	52,033	51,786	–0.1%	11.7%
Crawford	366	395	0.9%	29,481	24,602	–2.0%	19.3%
De Beque	451	543	2.1%	37,523	59,431	5.2%	8.1%
Del Norte	1,705	1,592	–0.8%	30,180	29,151	–0.4%	18.7%
Delta	6,400	9,253	4.2%	34,715	39,599	1.5%	16.3%
Dinosaur	319	338	0.6%	39,572	36,336	–0.9%	24.6%
Fruitvale	6,936	NA	NA	56,272	56,732	0.1%	5.7%
Fruita	6,478	12,274	7.4%	41,698	56,815	3.5%	9.9%
Glenwood Springs	7,736	9,107	1.8%	55,633	52,791	–0.6%	12.0%
Grand Junction	41,986	58,444	3.7%	41,980	46,460	1.1%	15.2%
Hotchkiss	968	1,095	1.4%	35,527	42,773	2.1%	9.9%
Meeker	2,242	2,469	1.1%	43,661	53,107	2.2%	4.4%
Monte Vista	4,529	3,992	–1.4%	35,954	29,787	–2.1%	21.9%
New Castle	1,984	4,145	8.5%	69,646	57,371	–2.1%	8.3%
Orchard City	2,880	3,239	1.3%	45,479	47,970	0.6%	9.7%
Orchard Mesa	6,456	NA	NA	51,772	51,465	–0.1%	9.0%
Palisade	2,579	2,931	1.4%	35,126	44,600	2.7%	11.5%
Paonia	1,497	1,649	1.1%	40,307	47,291	1.8%	11.4%
Parachute	1,006	1,288	2.8%	39,519	45,314	1.5%	19.9%
Rangely	2,096	2,188	0.5%	52,268	60,560	1.6%	7.0%
Redlands	8,043	NA	NA	67,789	67,490	0.0%	5.3%
Rifle	6,784	9,255	3.5%	54,114	72,824	3.4%	5.0%
Silt	1,740	2,693	5.0%	56,517	66,300	1.8%	6.5%
South Fork	604	526	–1.5%	46,431	44,383	–0.5%	11.8%

[a] Data are averages for the period 2005 to 2009.

[b] NA = data not available.

Sources: U.S. Census Bureau (2011e–h).

TABLE 3.11.2-8 ROI Urban Population and Income for the Utah ROI

City	Population 2000	Population 2009	Population Average Annual Growth Rate, 2000–2009	Median Household Income $ 2010 1999	Median Household Income $ 2010 2005–2009[a]	Median Household Income Average Annual Growth Rate, 1999 and 2005–2009	Individuals Living in Poverty[a]
Altamont	178	203	1.5%	36,406	37,529	0.3%	3.1%
Aneth	598	NA[b]	NA	21,897	25,955	1.9%	37.3%
Antimony	122	113	–0.8%	28,492	28,798	0.1%	40.0%
Ballard	566	759	3.3%	44,672	67,083	4.6%	11.3%
Bicknell	353	347	–0.2%	41,471	49,434	2.0%	2.8%
Blanding	3,162	3,292	0.4%	41,776	38,182	–1.0%	23.8%
Bluff	320	NA	NA	30,272	16,367	–6.6%	66.7%
Boulder	180	189	0.5%	37,989	45,249	2.0%	0.0%
Cannonville	148	137	–0.9%	36,406	47,855	3.1%	14.3%
Castle Dale	1,657	1,594	–0.4%	55,951	41,673	–3.2%	19.7%
Castle Valley	349	386	1.1%	41,874	41,201	–0.2%	15.5%
Clawson	153	175	1.5%	39,572	36,082	–1.0%	25.3%
Cleveland	508	522	0.3%	42,421	43,536	0.3%	8.7%
Duschesne	1,408	1,702	2.1%	41,061	47,741	1.7%	19.1%
East Carbon City	1,393	1,271	–1.0%	32,054	31,987	0.0%	7.9%
Elmo	368	370	0.1%	42,737	50,474	1.9%	7.2%
Emery	308	296	–0.4%	51,246	53,891	0.6%	3.2%
Escalante	818	757	–0.9%	40,703	41,597	0.2%	8.5%
Ferron	1,623	1,566	–0.4%	48,911	60,984	2.5%	15.8%
Fort Duchesne	621	NA	NA	23,743	23,624	–0.1%	29.9%
Halchita	270	NA	NA	12,505	10,550	–1.9%	72.9%
Halls Crossing	89	NA	NA	33,728	NA	NA	0.0%
Hatch	127	117	–0.9%	46,958	46,755	0.0%	1.7%
Helper	2,025	1,906	–0.7%	38,055	42,749	1.3%	4.5%
Henrieville	159	146	–0.9%	36,089	31,000	–1.7%	21.0%
Huntington	2,131	2,080	–0.3%	46,807	40,252	–1.7%	11.0%
La Sal	339	NA	NA	32,830	NA	NA	0.0%
Loa	525	514	–0.2%	42,737	40,021	–0.7%	1.7%
Lyman	234	230	–0.2%	46,355	38,660	–2.0%	9.9%
Maeser	2,855	NA	NA	51,638	76,513	4.5%	6.3%
Mexican Hat	88	NA	NA	73,010	NA	NA	0.0%
Moab	4,779	5,148	–0.8%	41,307	35,508	–1.7%	22.6%
Montezuma Creek	507	NA	NA	37,197	18,846	–7.3%	29.1%
Monticello	1,958	2,028	0.4%	45,497	38,929	–1.7%	9.9%
Myton	539	629	1.7%	29,722	35,574	2.0%	25.8%
Naples	1,300	1,751	3.4%	54,651	66,384	2.2%	8.5%
Navajo Mountain	379	NA	NA	17,976	44,722	10.7%	35.0%
Neola	533	NA	NA	48,390	66,105	3.5%	8.6%
Oljata–Monument Valley	864	NA	NA	40,760	43,500	0.7%	46.6%

TABLE 3.11.2-8 (Cont.)

	Population			Median Household Income			
				$ 2010			
City	2000	2009	Average Annual Growth Rate, 2000–2009	1999	2005–2009[a]	Average Annual Growth Rate, 1999 and 2005–2009	Individuals Living in Poverty[a]
Orangeville	1,398	1,361	–0.3%	57,055	37,933	–4.4%	10.6%
Panguitch	1,623	1,502	–0.9%	42,421	36,935	–1.5%	14.2%
Price	8,402	8,236	–0.2%	40,125	35,410	–1.4%	18.3%
Randlett	224	NA	NA	21,009	22,164	0.6%	44.6%
Roosevelt	4,299	5,466	2.7%	36,963	52,051	3.9%	14.6%
Scofield	28	26	–0.8%	33,240	28,798	–1.6%	0.0%
Spanish Valley	181	NA	NA	63,578	46,021	–3.5%	6.1%
Sunnyside	404	384	–0.6%	41,731	35,892	–1.7%	30.5%
Tabiona	149	171	1.5%	36,406	69,070	7.4%	1.8%
Torrey	171	192	1.3%	32,745	32,271	–0.2%	16.8%
Tropic	508	472	–0.8%	53,818	61,792	1.5%	7.4%
Tselakai Dezza	103	NA	NA	59,832	135,418	9.5%	0.0%
Vernal	7,714	9,225	2.0%	38,441	49,567	2.9%	10.1%
Wellington	1,666	1,601	–0.4%	49,826	41,580	–1.3%	15.7%
White Mesa	277	NA	NA	17,412	15,373	–1.4%	45.4%
White Rocks	341	NA	NA	13,191	16,517	2.5%	23.3%

[a] Data are averages for the period 2005 to 2009.

[b] NA = data not available.

Source: U.S. Census Bureau (2011e–h).

higher than the ROI average (1.2%) experienced in Ballard (3.3%), Roosevelt (2.7%), Duschesne (2.1%), Vernal (2.0%), Myton (1.7%), Tabonia (1.5%), Clawson (1.5%), Altamont (1.5%), and Torrey (1.3%). The remaining cities experienced lower growth rates from 2000 to 2009, with 21 cities experiencing negative growth rates during this period.

Median household incomes vary across cities in the Utah ROI. Over the period 2006 to 2009, Tselakai Dezza ($135,418), Maeser ($76,513), Tabonia ($69,070), Ballard ($67,083), Naples ($66,384), Neola ($66,105), Tropic ($61,792), and Ferron ($60,984) had median incomes that were higher than the state average ($57,144) (Table 3.11.2-8). Seven cities (Fort Duchesne, Randlett, Montezuma Creek, Whiterocks, Bluff, White Mesa and Halchita) had median household incomes that were less than half the state average, while more than 15% of individuals in 24 cities were living in poverty over the period 2005 to 2009, and more than 50% of the individuals in Halchita and Bluff were living below the poverty line.

The population of the Wyoming ROI in 2009 was 57.3% urban; the largest city, Rock Springs, had an estimated population of 20,905; other larger cities in the ROI include Green

River (12,411), Evanston (11,958), Rawlins (8,793), and Kemmerer (2,513) (Table 3.11.2-9). In addition, there are 53 smaller cities in the ROI with 2009 populations of less than 2,000.

Population growth rates in the Wyoming ROI have varied over the 2000 to 2009 period (Table 3.11.2-9). Alpine grew at an annual rate of 4.6% during this period, with growth rates higher than the ROI average experienced in Baggs (2.2%), Wamsutter (1.9%), Thayne (1.5%), La Barge (1.3%), and Rock Springs (3.5%). The remaining cities experienced lower growth between 2000 and 2009, with growth rates of less than 2%; eight cities had negative growth rates.

Median household incomes vary across cities in the Wyoming ROI. Over the period from 2006 to 2009, 25 cities, including Arrowhead Spring ($216,731), Farson ($91,794), North Rock Springs ($89,474), Etna ($87,555), Alpine Northwest ($83,369), and Bedford ($81,533) had median incomes that were higher than the state average ($52,843) (Table 3.11.2-9). Seven cities (Little America, Dixon, Robertson, Washam, Turnerville, Auburn, and Lonetree) had median household incomes that were less than half the state average, while more than 15% of individuals in nine cities were living in poverty over the period 2005 to 2009, and more than 50% of the individuals in Purple Sage were living below the poverty line.

3.11.2.2.4 Housing. Housing prices have risen rapidly in areas experiencing brisk population growth associated with oil and gas development. Rifle, Colorado, has witnessed "2% growth per month in the last three months," according to a Colorado mayor, and "26% over the last seven months," according to a Colorado county manager. Rental housing used by oil and gas drilling workers is "almost completely unavailable," with vacancy rates at about 2%, according to a Colorado realtor. Rental housing in Newcastle, Silt, Parachute, and Rifle is currently "all taken," and there are "no hotels" available because of the oil and gas boom, according to a Colorado county manager. Rental vacancy rates have changed significantly in the last 2 years, and for those able to find rental housing, rates "have doubled in the last two years." Home construction for oil and gas workers has been undertaken, often in areas annexed to smaller communities, together with speculative development of more expensive single-family homes, which are often priced at more than $500,000. Some local ranchers are selling 3- to 4-acre parcels to small builders, with homes then marketed locally and statewide. Homes are occupied by production workers, with some executives occupying higher-priced houses. There are numerous "overpriced" houses for sale, according to a Colorado realtor, producing an artificially high overall vacancy rate in state and federal statistics. Houses with three bedrooms and two bathrooms sell for $225,000 in Meeker, and for between $375,000 and $425,000 outside of town on 3 to 5 acres of land. Inflation in housing prices is "scary" to many potential buyers, according to a Colorado realtor, often meaning that houses are on the market for extended periods of time.

Affordable housing has become such "a critical issue" in Uintah County, Utah, "as part of the boom throughout Utah," that a housing specialist has been hired, according to a Utah city manager. Particularly hard hit are entry-level teachers (10 of whom recently rejected contracts because of housing issues), police officers, entry-level government workers, and retail sales workers. A plan has been suggested whereby the Uintah County School District buys housing in order to ensure affordable housing for teachers, while the idea of offering tax credits for housing

TABLE 3.11.2-9 ROI Urban Population and Income for the Wyoming ROI

City	Population			Median Household Income			Individuals Living in Poverty[a]
	2000	2009	Average Annual Growth Rate, 2000–2009	$ 2010: 1999	$ 2010: 2005–2009[a]	Average Annual Growth Rate, 1999 and 2005–2009	
Afton	1,818	1,906	0.5%	47,223	54,054	–0.5%	15.1%
Alpine	550	827	4.6%	57,380	67,337	1.8%	2.6%
Alpine Northeast	82	NA[b]	NA	54,346	54,995	0.1%	35.0%
Alpine Northwest	152	NA	NA	50,968	83,369	5.6%	0.0%
Arrowhead Springs	68	NA	NA	103,161	216,731	8.6%	0.0%
Auburn	276	NA	NA	41,946	17,416	–9.3%	31.6%
Baggs	348	423	2.2%	37,594	30,492	–2.3%	36.0%
Bairoil	97	98	0.1%	48,014	49,973	0.4%	8.8%
Bedford	169	NA	NA	51,246	81,533	5.3%	13.3%
Carter	8	NA	NA	15,301	NA	NA	0.0%
Clearview Acres	850	NA	NA	53,336	50,718	–0.6%	3.2%
Cokerville	506	501	–0.1%	40,148	65,304	5.6%	0.7%
Diamondville	716	679	–0.6%	49,807	40,974	–2.1%	11.3%
Dixon	79	82	–0.4%	30,075	24,775	–2.1%	22.8%
Eden	388	NA	NA	66,639	60,585	–1.1%	0.0%
Elk Mountain	192	201	–0.5%	51,048	48,279	–0.6%	12.0%
Etna	123	NA	NA	54,346	87,555	5.4%	6.5%
Evanston	11,507	11,958	–0.4%	53,208	51,205	–0.4%	9.2%
Fairview	277	NA	NA	45,040	32,186	–3.7%	0.0%
Farson	242	NA	NA	56,407	91,794	5.6%	0.0%
Fontenelle	19	NA	NA	NA	NA	NA	0.0%
Fort Bridger	400	NA	NA	40,561	54,378	3.3%	3.8%
Grand Encampment	443	NA	NA	37,285	NA	NA	NA
Granger	146	149	0.2%	58,962	72,419	2.3%	9.9%
Green River	11,808	12,411	0.6%	67,321	71,886	0.7%	8.1%
Grover	137	NA	NA	41,155	32,425	–2.6%	0.0%
Hanna	873	871	0.0%	46,048	37,480	–2.3%	8.2%
James Town	552	NA	NA	65,952	50,967	–2.8%	3.6%
Kemmerer	2,651	2,513	–0.6%	59,963	68,269	1.5%	3.0%
La Barge	431	483	1.3%	48,806	49,041	0.1%	14.6%
Little America	56	NA	NA	22,952	26,204	1.5%	0.0%
Lonetree	61	NA	NA	41,941	16,517	–9.8%	0.0%
Lyman	1,938	2,034	0.5%	64,011	65,863	0.3%	11.6%
McKinnon	49	NA	NA	101,577	NA	NA	0.0%
Medicine Bow	274	269	–0.2%	42,737	33,880	–2.5%	18.0%
Mountain View	1,153	1,235	0.8%	62,048	70,724	1.5%	0.0%
North Rock Springs	1,974	NA	NA	67,935	89,474	3.1%	6.8%
Oakley	18	NA	NA	80,198	NA	NA	0.0%
Opal	102	98	–0.4%	49,069	44,468	–1.1%	4.2%
Point of Rocks	3	NA	NA	52,235	NA	NA	0.0%

TABLE 3.11.2-9 (Cont.)

	Population			Median Household Income			
				$ 2010			
City	2000	2009	Average Annual Growth Rate, 2000–2009	1999	2005–2009[a]	Average Annual Growth Rate, 1999 and 2005–2009	Individuals Living in Poverty[a]
Purple Sage	413	NA	NA	40,905	54,208	3.2%	56.8%
Rawlins	8,538	8,793	0.3%	46,346	53,654	1.6%	7.9%
Reliance	665	NA	NA	50,257	62,107	2.4%	2.8%
Riverside	59	64	0.9%	60,940	76,412	2.5%	12.5%
Robertson	59	NA	NA	66,797	22,234	–11.5%	0.0%
Rock Springs	18,708	20,905	1.2%	53,924	66,898	2.4%	6.6%
Saratoga	1,726	1,778	0.3%	47,024	56,933	2.1%	10.3%
Sinclair	423	406	–0.5%	61,053	74,415	2.2%	2.1%
Smoot	182	NA	NA	40,867	42,273	0.4%	0.0%
Star Valley Ranch	776	696	–1.2%	60,758	67,261	1.1%	1.8%
Superior	244	242	–0.1%	58,566	27,824	–7.9%	6.6%
Sweeney Ranch	17	NA	NA	39,572	NA	NA	0.0%
Table Rock	82	NA	NA	61,732	NA	NA	0.0%
Taylor	90	NA	NA	48,119	NA	NA	0.0%
Thayne	341	389	1.5%	40,363	28,314	-3.9%	10.6%
Turnerville	155	NA	NA	66,933	21,331	–11.9%	20.2%
Wasmsutter	261	310	1.9%	45,112	67,655	4.6%	1.9%
Washam	43	NA	NA	114,108	21,771	–16.8%	28.0%

[a] Data are averages for the period 2005 to 2009.

[b] NA = data not available.

Source: U.S. Census Bureau (2011e–h).

has also been suggested. Many workers are using “campers and tents, or doubling or tripling up with relatives,” according to a Uintah County planner. There are “many people in between welfare recipients and those that afford $300,000 homes,” many of whom “are being told they will have to wait 6 months to qualify for a loan with the current mortgage crisis.” High staff turnover among local merchants is also “blamed on the housing crisis.” In Lincoln County, Wyoming, with median home prices at $290,000 in Kemmerer, the demand for new housing is so high that 300 new 900-ft^2 homes were sold for $190,000 before construction had started, according to a County commissioner.

Tourism and recreation in Rio Blanco County has created additional demand for housing, with people from elsewhere buying second homes, often renting for 1 to 2 years before buying, and with some selling in response to the “harsh winters,” according to a Colorado realtor. Some homes are bought by fishermen and hunters who are in search of “small town life.”

In Colorado, energy development companies have begun to address housing shortages with the development of employer-provided housing. However, although only local and no state approval is required for employer-provided housing of up to 24 workers in Garfield County, state approval for larger employer-provided housing areas "has not been requested," according to a Colorado county manager. A larger housing area of 125 workers has been permitted in Rio Blanco County. In Sweetwater County, Wyoming, employer-provided housing has also been planned, with housing for up to 400 persons permitted for BP, with housing also permitted for Questar, both for a 20-year period. Commuting distances for oil and gas workers in Utah are often between 60 and 100 mi, and with workers on 12 to 14 hour shifts, 15% of the workforce is rotated through local motels, and the remainder through trailer home employer-provided housing. Regardless of their size, worker housing areas are still likely to produce social impacts, in the opinion of local officials, such as drug, alcohol, and spousal abuse, and mental health issues. Some local officials would prefer more local community housing rather than employer-provided housing to take advantage of the benefits of a locally resident workforce. The development of separate local and oil and gas communities has led to suspicion of oil and gas workers in local communities, resulting in having "to lock doors," while preferring "to leave doors open and trust everyone."

Housing stock in the Colorado ROI grew at an annual rate of 1.8% over the period of 2000 through 2009 (Table 3.11.2-10), with 102,004 total housing units in 2009. The rate of growth in vacant units (3.1%) was higher than the overall rate of growth in the ROI, while the annual growth in both owner-occupied and rental units stood at 1.7%.

TABLE 3.11.2-10 ROI Housing Characteristics

	Number of Units		
Parameter	2000	2009	Annual Average Growth, 2000–2009
Colorado ROI			
Owner-occupied	57,685	67,261	1.7%
Rental	22,714	26,539	1.7%
Vacant	6,228	8,204	3.1%
Total	86,627	102,004	1.8%
Utah ROI			
Owner-occupied	26,187	28,822	1.1%
Rental	6,929	9,160	2.4%
Vacant	8,853	8,841	0.0%
Total	42,469	46,823	1.1%
Wyoming ROI			
Owner-occupied	24,356	26,341	0.9%
Rental	7,967	9,036	1.4%
Vacant	6,747	6,962	0.3%
Total	39,070	42,339	0.9%

Sources: U.S. Census Bureau (2011c,d).

Annual growth in housing in the Utah ROI in the 2000 through 2009 period was 1.1%, with 46,823 total housing units in 2009. The annual rate of growth in rental units (2.4%) was higher than the overall rate of growth in the ROI. Annual growth in owner-occupied units was lower at 1.1%, and there was no growth in the number of vacant units in the ROI between 2000 and 2009.

In 2009, there were 42,339 total housing units in the Wyoming ROI. The ROI housing market grew at an annual rate of 0.9% over the 2000 through 2009 period. The rate of growth in rental units (1.4%) was higher than the overall rate of growth in the ROI (0.9%). The number of owner-occupied units grew during the 2000s by an average of 0.3% annually, and the number of vacant units in the ROI increased slightly.

Statistics presented on housing vacancy rates are based on the total number of vacant housing units. In some areas of each ROI, rental vacancy rates may be lower than the published rate because there may be numbers of owner-occupied housing units that were for sale, or were occupied only seasonally or were second homes, and, therefore, recorded as vacant, when the data were collected.

3.11.2.2.5 Fiscal Conditions. Funding infrastructure during oil and gas development can put local jurisdictions under enormous financial pressure, and although some oil companies have contributed to the cost of new roads where there is no existing access to drilling areas in some areas, there often has been little support from energy companies where existing roads need to be upgraded. With the pace of energy development, local governments are experiencing difficulties funding infrastructure improvements, with escalation in the price of construction materials, particularly of gravel, in Garfield County increasing the cost of a two-lane road "from $1 to $2.5 million/mile," according to a Colorado county manager. While the county can get help from the state, which provides energy impact funds from severance tax revenues, with "$0.5 million provided per project," the county has to provide matching funds, only some of which have come from increased property tax revenues; paying for upgraded infrastructure "can be difficult," according to a Colorado county manager. Other sources of revenues, such as sales taxes, are often dedicated to other areas, such as public libraries. Some municipalities receive recirculated state sales taxes for roads. In Colorado, severance taxes are currently distributed directly to impacted communities based on energy worker residential locations, but with many workers living in Craig and Grand Junction and bussed in every day, the problem of providing infrastructure and service where they are used is exacerbated. Recently, three new road projects were put out for bid by Garfield County, and "none were taken," which, combined with a shortage of construction workers, means that county authorities are "losing a never-ending struggle," according to a Colorado county manager, to keep up with oil and gas development.

In Utah, mineral lease funds paid to the federal government are "distributed equitably" by the Community Impact Board to local jurisdictions, according to a Utah city manager, and are used to pay for water and sewer service, educational facilities, fire stations, recreation facilities, a shelter for women and the homeless, and administration buildings. In Vernal, the Board has not provided support for housing development to local communities, instead preferring to send dollars "to housing authorities, not us," according to a Utah city manager. Sales taxes "make up for shortfalls" from mineral lease payments. To offset the impact of energy development, mitigation plans were used during the White River oil shale boom before any royalty payments were available from energy production. Despite the flow of funds to local authorities affected by oil and gas development in both states, planning for the mitigation of impacts in the form of infrastructure development and provision of public services does not occur until oil and gas "development levels and timing are obvious," according to a Utah city manager. Although mitigation agreements exist between gas companies and local governments, many companies "are not sharing information" on crucial issues, such as development schedules. Various programs are used by oil and gas companies to help mitigate the impact of rapid resource development in each ROI, often in the form of financial assistance to local jurisdictions to offset the increasing cost of providing services. In Colorado and Utah, oil companies have provided wide-ranging help with the cost of road repair and upgrading to support higher traffic levels. In Lincoln County, Wyoming, companies provided $1.6 million for snow removal in 2007, and through the Hathaway Fund provide $7,000 per semester to graduating seniors with high grade point averages, according to a county commissioner.

The diversion of tax revenues away from areas suffering many of the adverse impacts of rapid energy development, primarily to areas with larger populations, was a significant issue at the county level, and has led to "resentment," according to a Uintah County planner. Although counties may collect property tax and ad valorem tax revenues, sales taxes and Community Impact Board funds are intended to help cities. Severance taxes are collected and distributed by the state, although these are used to mitigate impacts on county roads, according to a Duschesne County planner. A particular problem lies in funding the county school system, where land on which schools are built is held by a special trust and supported by a special royalty system. Revenues are circulated "to areas with the largest population base," and the county school system "can't get things done without support from Salt Lake City legislators." In Wyoming, there are also conflicts in the allocation of resources among counties and communities for mitigation of impacts of oil and gas development, with many nonmineral counties in the state, many of which are dependent on agricultural interests, and many counties that do not have significant natural resources, and, therefore, receive more state government funds.

Table 3.11.2-11 shows the current expenditures by the various local government jurisdictions in each ROI and in each state.

3.11.2.2.6 Public Service Employment. In addition to problems securing adequate funding for infrastructure development with energy development and the associated rapid growth rates in local population, differences in rates of pay between energy and nonenergy occupations mean that there are significant labor shortages in numerous service industries, such as restaurants, car dealerships, and auto repair, and in local government, where teaching, health, public safety, road and bridge, and fire personnel positions are difficult to staff.

Table 3.11.2-12 presents data on levels of service (number of employees per 1,000 population) for public safety and general local government services and employment. Table 3.11.2-13 provides health services data, and Table 3.11.2-14 provides data on school district staffing and performance indicators.

3.11.2.2.7 Social Disruption. Social problems associated with rapid population growth with the development of energy extraction and power generation projects in small rural communities were first studied extensively in the 1970s and 1980s. Gilmore and Duff (1975) and Gilmore (1976), for example, found that rapid growth led to higher divorce and school dropout rates, suicide attempts, social alienation and isolation, juvenile delinquency, and crime, while Gold (1982) found that resource developments led to a weakening of social ties in the local community. Other studies suggested that boomtown growth was responsible for deterioration in the mental health of existing long-term residents and of in-migrants (Lantz and McKeown 1977; Dixon 1978; Weisz 1979; Freudenburg et al. 1982). Increases in crime, violence, and deviance were reported by Lantz and McKeown (1977), Little (1977), and Dixon (1978). Changes in the level of community integration were also studied (Little 1977; Jirovec 1979; Boulding 1981), as were changes in community satisfaction (Murdock and Schriner 1979). Drawing on the ideas of Ferdinand Toennies on the transition of small rural communities through industrialization and urbanization (Toennies 1887), it was often suggested that these changes occurred as a result of the breakdown of established informal social structures in small rural communities and the inadequacy of new, formal social institutions to provide social integration and social control (Cortese and Jones 1977; Little 1977; Moen et al. 1981; Cortese 1982).

The relationship between rapid energy boomtown growth and social disruption came under closer scrutiny in the early 1980s. It was suggested that many of the earlier studies relied on poorly documented or unreliable data and assertions on the nature and extent of boomtown social problems, preferring to accept the presence of social disruption largely in the absence of reliable evidence (Wilkinson et al. 1982). Problems with research design in many of the earlier studies also were highlighted, in particular, the tendency to base research findings on data collected in single communities rather than in numerous communities affected by energy developments (Krannich and Greider 1984), and the use of cross-sectional rather than longitudinal data to chart community social change over time (Brown et al. 1989).

TABLE 3.11.2-11 State and ROI Public Service Expenditures

Location	2005 ($ millions)
Colorado	
ROI	416.8
Colorado	39,481
Utah	
ROI	215.4
Utah	19,455
Wyoming	
ROI	268.8
Wyoming	5,638

Sources:

Colorado—City of Craig (2003); City of Delta (2004); City of Fruita (2005); City of Glenwood Springs (2004); City of Grand Junction (2004); City of Rifle (2004); Colorado State Demography Office (2007); Delta County (2005); Mesa County (2003); Moffat County (2005); Rio Blanco County (2005); Town of Meeker (2005); Town of Parachute (2005); Town of Rangely (2004); Town of Silt (2005).

Utah—Carbon County (2004); City of Moab (2006); Duchesne County (2004); Emery County (2004); Garfield County (2004); Grand County (2004); Price Municipal Corporation (2005); Roosevelt City Corporation (2005); San Juan County (2004); Uintah County (2004); Utah Governor's Office of Planning and Budget (2006); Vernal City Corporation (2005); Wayne County (2004).

Wyoming—Carbon County (2006); City of Evanston (2005); City of Green River (2004); City of Kemmerer (2005); City of Rawlins (2005); City of Rock Springs (2005); Lincoln County (2006); Sweetwater County (2005); Uinta County (2005); Wyoming Department of Administration and Information (2006).

Overall—Standard and Poor's (2006); U.S. Census Bureau (2011b,d).

TABLE 3.11.2-12 State and ROI Local Government Employment, 2009 (2006[a])

	Police		Fire[c]		General[a,d]	
Location	Number	Level of Service[b]	Number	Level of Service	Number	Level of Service
Colorado						
ROI	226	0.9	163	0.6	3,263	14.1
State	9,179	1.9	4,980	1.0	173,392	36.1
Utah						
ROI	160	1.4	13	0.1	1,254	13.2
State	3,576	1.4	1,575	0.6	73,357	28.4
Wyoming						
ROI	117	1.2	57	0.6	1,384	15.5
State	1,188	2.3	372	0.7	31,428	61.0

[a] ROI and state general government employment data are for 2006; state-level police and fire employment data are for 2006.

[b] Level of service represents the number of employees per 1,000 persons in each geographic unit.

[c] The number of firemen does not include volunteers.

[d] Total employment does not include teachers, physicians, or health workers.

Sources: FBI (2011); Fire Departments Network (2011); U.S. Census Bureau (2011b,d).

Subsequent work replaced the widespread sense of "alarmed discovery" prevalent in earlier research by more cautious and systematic approaches to the analysis of social change (Smith et al. 2001). Much of the focus became the study of multiple communities in order to separate and understand social change affecting boomtowns and those affecting communities outside energy development regions (England and Albrecht 1984; Freudenburg 1984; Krannich and Greider 1984; Greider and Krannich 1985; Brown et al. 1989; Berry et al. 1990).

Numerous studies have found that rapid growth led to certain forms of social disruption. Brown et al. (1989) found that boomtown growth led to community dissatisfaction, while England and Albrecht (1984) and Greider and Krannich (1985) found evidence of dissatisfaction with community facilities and services. Freudenburg (1986) and Brown et al. (1989) found higher fear of crime in boomtown communities than elsewhere. Brown et al. (1989) also found a reduction in local friendship ties and increases in residential transiency. Greider et al. (1991) found increased isolation, while Greider and Krannich (1985) found a decline in social support among residents of boomtown communities compared with more stable communities. The conclusions of these studies are quite different from those of earlier work on boomtowns, and indicate that periods of rapid population growth are not necessarily associated with social disruption and change in small rural communities.

TABLE 3.11.2-13 State and ROI Public Health Employment, 2010[a]

Location	Physicians: Number	Physicians: Level of Service[b]
Colorado		
ROI	787	3.0
State	12,027	2.6
Utah		
ROI	118	1.0
State	5,156	2.1
Wyoming		
ROI	106	1.1
Wyoming	1,008	2.0

[a] Data for Colorado are for 2003.

[b] Level of service represents the number of employees per 1,000 persons in each geographic unit.

Sources: AMA (2011); U.S. Census Bureau (2011e).

TABLE 3.11.2-14 State and ROI Education Data, 2010[a]

Location	Teachers	Student-to-Teacher Ratio[b]	School Dropout Rates
Colorado			
ROI	2,601	17.8	27.3
State	65,305	16.9	30.2
Utah ROI	1,150	20.6	21.9
Utah	35,238	15.9	19.5
Wyoming ROI	1,348	13.1	25.2
Wyoming	10,774	15.9	27.8

[a] ROI data are for 2010; state data are for 2004. Data on school dropout rates are for 2006.

[b] The student-to-teacher ratio is the number of students per teacher; dropout rates are based on data for the last three high school grades.

Sources: Standard and Poor’s (2006); NCES (2011).

In addition to studies of impacts across multiple communities, various longitudinal studies of social change also were made. Data collected in communities experiencing rapid growth indicate that divorce and crime rates did not increase significantly (Brookshire and D'Arge 1980; Wilkinson 1983; Wilkinson et al. 1984), although there were increases in delinquency during boom years (Wilkinson and Camasso 1984). Freudenburg and Jones (1991) showed increases in victimization rates in some communities, although Krannich et al. (1989) found no increases in victimization during boom years in several energy communities.

While it is clear that some level of social disruption seems to have occurred during boom years, underlying social structures may not have fundamentally changed. England and Albrecht (1984), for example, found no evidence of the replacement of informal social ties common in rural areas with formal association found in urban areas. Informal and external ties may actually strengthen with length of residence, and boomtown development may facilitate rather than diminish informal social ties. England and Albrecht (1984) found no dramatic shift in community perceptions during years of population growth, and Seyfrit and Sadler-Hammer (1988) found only a limited connection between rapid growth and changing youth attitudes toward community and family. Berry et al. (1990) suggest that interactions among neighbors during rapid growth periods are relatively stable, while Greider et al. (1991) reported no large increases in the level of distrust among neighbors, and that increasing heterogeneity accompanying rapid population growth does not significantly decrease neighboring interaction (Greider and Krannich 1985). Residents of rapidly growing communities may experience expanded opportunities for obtaining social support beyond their local neighborhood, while at the same time maintaining adequate relations with their neighbors.

Rapid population growth seems to have had differential effects across social groups. Freudenberg (1984) considered the effects of social change across different social groups and found no differences in attitudes between adults in boomtowns and in neighboring communities, but noted higher levels of dissatisfaction and alienation among boomtown adolescents. Krannich and Greider (1984) noted deterioration in perceived social integration among temporary mobile home residents in boomtown communities.

Studies of the long-term effects on community attitudes and perceptions show varying levels of community social disruption during the different phases of energy development, with examination of social disruption including the boom, decline, and post-boom recovery periods. The disruptive effects associated with boom growth may not have been permanent in some communities, dissipating in the years after the boom phase ended (Smith et al. 2001), while community satisfaction often has rebounded after declining during boom growth periods, producing an improvement in the sense of community well-being at the end of the boom period (Brown et al. 2005). The decline in the sense of community identity and solidarity during periods of instability caused by rapid population growth rebounded fairly quickly with the return to more stable growth (Greider et al. 1991).

Social Disruption Impacts in Relevant NEPA Documents. Social impacts are not considered in any detail in the various NEPA-related assessments that have been made since the early 1970s of the potential impacts of shale/tar sands projects and other relevant large-scale energy resource developments. Consequently, there is little indication from these documents of the extent to which proposed oil shale and tar sands developments would produce social disruption in local communities located near these facilities.

In the *Final Environmental Impact Statement for the Prototype Oil Shale Leasing Program* (DOI 1973), it is recognized that community structures and organizations will be affected, together with community social structures and lifestyles. However, beyond a brief description of potential problems in the local community adjusting to the influx of in-migrants, and the impacts of contrasting urban and rural lifestyles and potential impacts on crime, cultural and social change are judged to be highly subjective in nature and therefore difficult to adequately measure. Subsequent EISs also recognize the potential social disruption associated with oil shale development. The *Final Programmatic Environmental Impact Statement on Development Policy Options for the Naval Oil Shale Reserves in Colorado* (DOE 1982), for example, suggests that rapid population growth and cultural differences between resident and nonresident groups may lead to social problems and social conflict. Alcoholism, drug abuse, mental illness, divorce, and juvenile delinquency are mentioned as potential impacts of rapid population growth associated with oil shale development, but no data or analysis are presented.

The *Final Environmental Impact Statement on Uintah Basin Synfuels Development* (BLM 1983c) uses evidence of social impacts associated with oil and gas development to suggest that additional development would lead to deterioration in attitudes toward quality of life, notably with respect to the management of local growth, particularly on Indian reservations. The *Utah Combined Hydrocarbon Leasing Regional Environmental Impact Statement* (BLM 1984b) also draws attention to potential impacts associated with changes in lifestyle with decreasing local cultural homogeneity, particularly social alienation that might be experienced on Indian reservations.

In the absence of social baseline data, a number of EISs have suggested that social disruption is likely to occur once an arbitrary population growth rate associated with oil shale development has been reached. The Green River–Hams Fork EIS (BLM 1980) assumes that an annual rate of 10% would result in a breakdown in social structures, with a consequent increase in alcoholism, depression, suicide, social conflict, divorce, delinquency, and deterioration in levels of community satisfaction. In addition to population growth rates, the EIS suggests that cultural dissimilarities between existing and new residents and the perceived political helplessness of local residents also cause social disruption. The *Final Supplemental Environmental Impact Statement for the Prototype Oil Shale Leasing Program* (BLM 1983a) supports the growth rate approach to identifying communities likely to suffer social disruption, also indicating potential elements of social disruption that may affect small rural communities.

3.11.2.2.8 Social Change. Although an extensive literature in sociology documents the most significant components of social change in energy boomtowns, the nature and magnitude of the social impact of energy developments in small rural communities are still unclear. While some degree of social disruption is likely to accompany large-scale in-migration during the boom phase, there is insufficient evidence to predict the extent to which specific communities are likely to be impacted, which population groups within each community are likely to be most affected, and the extent to which social disruption is likely to persist beyond the end of the boom period (Smith et al. 2001).

A significant issue for local communities during oil and gas development is the lack of "commitment to the county" of many migrant workers, according to a Colorado county manager and Wyoming County planner. Many construction workers do not bring family members to the area, and this has led to "social issues," requiring an additional 33 social workers in Garfield County, often to deal with "child welfare issues," in particular, the collection of child support payments, according to a Colorado county manager. There has also been an increase in the number of sheriff's deputies to combat increases in gang-related crime.

While much of the literature on social disruption assesses the impact of energy and other large-scale developments on small, stable, isolated rural communities, many communities in the three ROIs have experienced extensive growth and development during the recent past associated with oil and gas development, tourism and recreation, and retirement and second home development. Given the scale of these developments, it is likely that some degree of social disruption may have already occurred in a number of communities, particularly in the Colorado ROI.

There are various measures of social change, including violent, drug-related, and juvenile crime rates; alcoholism and illicit drug use; divorce rates; and mental illness.

Crime rates vary between each ROI and each state (Table 3.11.2-15). Data for 2004 show that violent crime rates were lower in the Colorado and Utah ROIs than they were in Wyoming, with rates of 1.2 incidents per 1,000 population in the Colorado ROI and 1.6 per 1,000 in Utah, compared with 2.3 per 1,000 in Wyoming. Rates of violent crime are higher in the state as a whole in Colorado and Utah than in the ROI in each state, while rates in Wyoming as a whole are lower than in the Wyoming ROI. Drug-related crime data are only available at the ROI level for Colorado, and show a slightly lower level in the ROI (3.9 incidents per 1,000 compared with 4.2 per 1,000 in the state). Juvenile crime is lower in each ROI than in the corresponding state, with 22.6 incidents per 1,000 in Colorado, 13.8 per 1,000 in the Utah ROI, and 5.1 in the Wyoming ROI. Overall crime rates are higher in the Utah ROI (67.5 incidents per 1,000) than in Colorado (30.9) and Wyoming (27.2). Over time, it would appear that crime rates in the Colorado and Wyoming ROIs are declining, with lower rates per 1,000 population in 2004 compared with 2001 for each category of crime in the Colorado ROI, and violent, juvenile, and total crime in the Wyoming ROI. Rates in the two states have also declined between the same 2 years.

Although statistics on alcoholism, drug use, divorce, and mental health are not available for each ROI, data for each state may provide some information on social change in each ROI. Rates of alcoholism are higher in Colorado (9.2% of the total population with dependence or abuse of alcohol) and Wyoming (9.4%) than in the United States as a whole (7.6%), while rates in Utah (7.3%) are lower than in the other two states and in the nation (Table 3.11.2-16). Rates of drug use in Colorado (3.3% of the total population with dependence or abuse of illicit drugs) and Utah (3.5%) are slightly higher than the rate for Wyoming (2.9%), and both are higher than the national average (3.0%). Divorce rates in Colorado (4.7 per 1000 population) and Wyoming

TABLE 3.11.2-15 State and ROI Crime Rates[a]

	Violent Crime		Drug Crime		Juvenile Crime		Total Crime	
Location	2001	2004	2001	2004	2001	2004	2001	2004
Colorado								
ROI	1.2	1.2	5.7	3.9	32.3	22.6	45.6	30.9
State	1.6	1.4	4.5	4.2	40.3	32.8	55.0	50.4
Utah								
ROI	NA[b]	1.6	NA	NA	NA	13.8	NA	67.5
State	NA	2.3	NA	NA	NA	11.8	NA	51.6
Wyoming								
ROI	2.4	2.3	NA	NA	7.6	5.1	31.0	27.2
State	1.2	1.0	NA	NA	10.9	9.3	52.2	52.7

a Rates are the number of crimes per 1,000 population.

b NA = not available.

Sources: Colorado Bureau of Investigation (2006); Utah Department of Public Safety (2006); Wyoming Division of Criminal Investigation (2006).

TABLE 3.11.2-16 State Indices of Social Change, 2004[a]

Location	Alcoholism	Illicit Drug Use	Divorce[b]	Mental Health
Colorado	9.2	3.3	4.7	11.4
Utah	7.3	3.5	4.1	14.6
Wyoming	9.4	2.9	5.4	13.3
United States	7.6	3.0	4.1	9.6

a Data for alcoholism, drug use, and metal health represent percent of the population over 12 years of age with dependence or abuse of alcohol, illicit drugs, or suffering from serious psychological distress. Data are for 2005.

b Divorce rates are the number of divorces per 1,000 population.

Sources: SAMHSA (2006); CDC (2006).

(5.4%) are slightly higher than the national average (4.1%) and the rate for Utah (4.1%). Data for mental health show that for Colorado, 11.4% of the population suffered from serious psychological stress, with slightly higher rates in Wyoming (13.3%) and Utah (14.6%), rates that were higher than in the nation as a whole (9.6%).

3.11.3 Recreation Economy

Large areas both within, and in the vicinity of, the oil shale and tar sands ROIs in Colorado, Utah, and Wyoming administered by the BLM, USFWS, NPS, U.S. Department of Transportation (DOT), USFS, and BOR are used for recreation, primarily hunting and other forms of dispersed outdoor activities. Table 3.1.2-1 lists the many recreational areas and other areas that may provide recreation opportunities located within about a 50-mi radius of the oil shale and tar sands resources.

Statistics available at the state level show that in 2001 almost 1.2 million people participated in hunting and fishing in Colorado, of whom 60% were state residents, and 1.6 million participated in wildlife watching (USFWS 2002c). In Utah, participation in these activities was lower, with 517,000 fishermen and hunters, 80% of whom, on average, were state residents, and 806,000 people wildlife watching. In Wyoming in 2001, there were 293,000 anglers and hunters, 45% of whom, on average, resided in the state, and 498,000 wildlife watchers.

Numerous popular state parks are located in the vicinity of federally administered land near oil shale and tar sands developments. Three facilities in the state located in the oil shale and tar sands ROI—Anasazi Indian Village State Park, Dead Horse Point State Park, and Edge of the Cedars State Park—were together visited by 255,766 people in 1999 (Utah State Legislature 2000).

Hunters and anglers spent an estimated $797 million on trip expenses and related equipment in Colorado in 2002, almost 60% of which came from state residents, while the Colorado Department of Wildlife spent an additional $49 million on operations to support hunting and fishing (BBC Research and Consulting 2004). Once the indirect impacts on the remainder of the state economy of trip-related expenditures are included, hunting and fishing had an overall impact on the state of $1.5 billion, and supported 20,000 jobs. The overall impact of wildlife watching, including indirect impacts, on the state was $940 million, supporting 13,000 jobs.

Because public land in the three-state ROI is primarily used for hunting and other forms of dispersed outdoor activities, the number of visitors using these lands for these recreational activities is not available from all administering agencies; that is, the value of recreational resources in these areas, based solely on the number of recorded visitors, is likely to be underestimated. In addition to visitation rates, the economic valuation of certain natural resources can also be assessed in terms of the potential recreational destination for current and future users, that is, their nonmarket value. Another method is to estimate the economic impact of the various recreational activities supported by natural resources on public land in the vicinity of land proposed for oil shale and tar sands development.

3.11.3.1 Economic Valuation of Public Lands Used for Recreation

A simple way to quantify the value of recreation on public land would be to measure revenue generated by user fees and other charges for public use. However, visitation statistics are often incomplete, and, in many cases, federal and state agencies do not charge visitors a fee for entrance to recreational resources on public lands; where fees are charged, they may be nominal compared with the value of the visit to recreational users. Recreation undertaken using privately owned facilities, such as golf courses, horse ranches, or fishing on private waters, has a quantifiable market value, with the user paying rates for visiting these facilities, which reflect the value of the resource to its owners and the cost of providing access to it to visitors. With the majority of recreation in the immediate vicinity of proposed oil shale and tar sands facilities likely to occur on public lands, however, the economic value of these resources is more difficult to quantify, since no valuation of the use of these resources can be made through the marketplace.

A number of methods have been used to determine the use value of non-marketed recreational goods, or the value of recreational resources on public lands that may be for used for recreation. Because resources on public lands are scarce, and recreational activities provide enjoyment and satisfaction, the amount visitors would pay over the actual cost of using these resources represents the value of the benefit of these resources to the public. One method of estimating the net willingness to pay, or consumer surplus, associated with resources on public lands used for recreation is the travel cost method. This method uses variation in the cost of traveling different distances, and the number of trips taken over each distance, as a way to represent the demand for recreational resources in any given location (Loomis and Walsh 1997).

In addition to use values, a certain portion of the value of resources used for recreation may lie in the passive use of a resource, or the extent of the availability of the resource to current and future generations. Attempts to establish passive use values, or the willingness to pay for, or accept compensation for the loss of, different levels of nonmarketed recreational resources on public lands have used contingent valuation methods, which rely on telephone interviews or questionnaire surveys. Typically, a description of a particular resource is presented to respondents, who are then asked to place a dollar value on their use of the resource, or on the preservation of the resource (Loomis 2000). Although the travel cost and contingent valuation methods have weaknesses, particularly with regard to the accuracy of questions asked and respondents' self-reporting errors, both have been used widely by government agencies and academics in cost-benefit analyses of outdoor recreation. The BOR, for example, used contingent valuation to place a value of the impact of hydropower activities in Utah and Colorado on fishing and rafting (BOR 1995). The method was used in establishing the value of natural resources damaged by oil spills in Alaska (DOI 1994; Carson et al. 1992), and various state agencies have used the travel cost and contingent valuation methods for valuing wildlife-related recreation (Loomis 2000). Contingent valuation methods have also been used to value natural resource amenities, such as improvements in visibility in the Grand Canyon (Schulze and

Brookshire 1983) and the value of protecting endangered species (Boyle and Bishop 1987) and wilderness areas (Koontz and Loomis 2005).

Loomis (2000) reports the results of various studies that used survey data and travel cost and contingent valuation methods to estimate the value of recreation in wilderness areas in Colorado and Wyoming. On the basis of data reported in these studies, the average value per day of visiting a wilderness area for recreation was estimated to be $26 (1996 dollars), meaning that a visitor would be willing to pay this amount more than trip travel cost rather than lose a day visiting an area for recreation. Multiplying this number by the number of visitors to a specific wilderness resource would give the value of the resource to the public (Loomis 2000).

Contingent valuation has also been used to establish willingness to pay to preserve existing wilderness areas, and additional acreage that might be designated as wilderness. On the basis of two surveys of Colorado and Utah residents, Walsh et al. (1984) and Pope and Jones (1990) found that passive use values varied with the level of wilderness already designated in a state, but at a decreasing rate. Passive use value was also found to represent about half of the economic value of a resource, equaling the use value of the resource to the household as a place for recreation. The same surveys found that residents in Colorado and Utah, and in the rest of the United States, would pay between $220 per additional acre, if 5−10 million acres of wilderness resources were to be preserved in the two states, and $1,246 per acre if only 1.2 million additional acres were preserved. Passive use values in the western United States were estimated to be $168 per acre, or about $7.2 billion when applied to all wilderness land in the west. Barrick (1986) estimated the value of the wilderness resources in the Washakie Basin, Wyoming, for future visits (option values) at $69 (1996 dollars) for on-site users, and $15 and $13 for urban and rural nonvisiting U.S. residents, respectively.

3.11.3.2 Economic Impact of Recreational Activities

The economic value of recreation in the oil shale and tar sands areas in each state can be estimated through the impact recreation has on the economy of the ROI in each state by identifying sectors in the ROI (see Table 3.11.3-1) economy in which expenditures on recreational activities occur. Not all activities in these sectors are directly related to recreation on federal lands, with some expenditures made by business visitors, oil and gas workers, and interstate travelers, and some activity occurring on private land (e.g., dude ranches, golf courses, bowling alleys, and movie theaters).

Expenditures associated with recreational activities form an important part of the economy of the ROIs and states in which they are located. In 2004, 10,970 people were employed in the Colorado ROI in the various sectors identified as recreation, constituting 14% of total ROI employment (Table 3.11.3-1). Recreation spending also produced almost $123 million in income in the ROI in 2004. The recreation sector was smaller in the Wyoming ROI (4,486 persons employed, producing almost $50 million in income), although it represents a larger share (15.5%) of total ROI employment, and in Utah (3,227 employed, and almost $24 million in income), it contributed 10% of total ROI employment in 2004.

TABLE 3.11.3-1 ROI Recreation Sector[a] Activity, 2004

ROI[b]	Employment[b]	Share of ROI Employment	Income ($ million)
Colorado	10,970	14.0%	122.9
Utah	3,227	10.7%	23.9
Wyoming	4,826	15.5%	49.6

[a] The recreation sector includes amusement and recreation services, automotive rental, eating and drinking places, hotels and lodging places, museums and historic sites, recreational vehicle parks and campsites, scenic tours, and sporting goods retailers.

[b] The Colorado ROI includes Delta, Garfield, Mesa, Moffat, and Rio Blanco Counties; the Utah ROI includes Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Uintah, and Wayne Counties; the Wyoming ROI includes Carbon, Lincoln, Sweetwater, and Uinta Counties.

3.11.4 Transportation

3.11.4.1 Colorado

I-70 and Colorado State Highway 64 are the major east–west arterials bounding the general area of the Piceance Basin oil shale resource area in Colorado on the south and north, respectively. On the east side of the Basin is Colorado State Highway 13, the major north–south arterial. Rio Blanco County Roads such as 5, 24, 26, 29, 69, 85, 91, 122, and 144, which provide access to the basin interior, are accessed from State Highways 13 and 64. On the west side of the basin is north–south State Highway 139; this arterial, however, does not provide ready access to the interior of the oil shale area. There are numerous lesser gravel or dirt rural roads within the Piceance Basin that are used primarily by recreationists, ranchers, and oil and gas operators.

I-70, in addition to being a major east–west national corridor, is the major access between Denver and the winter and summer recreation areas in central Colorado. During peak use times and during inclement weather, primarily in the winter, traffic on I-70 is very congested and slow. Complicating this situation is the increasing amount of commuter traffic that supports both recreational tourism in central Colorado and the growth related to current oil and gas development on the Western Slope. For some time, Colorado has been addressing possible actions that could be employed to minimize the current congestion in this corridor.

With the growth of the oil and gas industry in recent years, traffic in the Piceance Basin has increased markedly. Well drilling equipment, pipeline construction equipment, and construction and production traffic travel along these roads throughout the day. These roads were originally designed for rural and agricultural uses and were not intended for heavy loads and traffic volumes associated with oil and gas production and construction. The increasing traffic volume, frequency, and vehicle size on these rural roads has contributed to an increase in the costs associated with repair and maintenance of these county roads.

Table 3.11.4-1 gives average daily traffic numbers in 2005 compiled from the Colorado Department of Transportation (CDOT) and the Garfield and Rio Blanco County Road and Bridge Department for major roads in the Piceance Basin.

Repair and maintenance of county roads represents the single largest dollar impact on Rio Blanco County (Exxon Mobil 2006). These county roads, originally designed for rural and agricultural uses, are experiencing increased traffic volume, frequency of use, and size of vehicles. The commuting workforce and oversized loads typical of the oil and gas industry have contributed to the increased costs associated with repair and maintenance, particularly in the Piceance Basin area.

3.11.4.2 Utah

The primary access for the Uinta Basin oil shale and tar sands resources from the north is via U.S. Highways 40 and 191, and from the south via I-70. The major routes into the basin from U.S. Highways 40 and 191 are local roads 45 and 88 south from U.S. 40. U.S. Highway 6 parallels the southwest side of the Uinta Basin, and Road 123 links this highway with the interior of the basin in the vicinity of the Sunnyside STSA. Access to the San Rafael STSA is from I-70, which traverses that area. Access to the Tar Sand Triangle STSA is from Highways 24 and 95. There also are numerous other gravel or dirt rural roads within the Uinta Basin and tar sands resource areas that are used primarily by recreationists, local ranchers, and oil and gas operators.

TABLE 3.11.4-1 Baseline Average Daily Traffic Data for Study Area Roads

Road	Baseline Average Daily Traffic (number of vehicles per day)
Colorado Highway 13 between Rifle and the junction with the south end of Rio Blanco County (RBC) Road 5 (Piceance Creek Road)	2,300[a]
Colorado Highway 13 between south end of RBC Road 5 and Colorado Highway 64 near Meeker	2,300[a]
Colorado Highway 64 between Meeker and north end of RBC Road 5	830[a]
Colorado Highway 64 between north end of RBC Road 5 and Colorado Highway 139	1,700[a]
I-70 from Rifle to Grand Junction	14,300–23,100[a]
RBC Road 5 (Piceance Creek Road)	562–1,076[b]

[a] CDOT (2004).

[b] Lower traffic range was measured in May, and high traffic range was measured in late October/early November, coinciding with big game hunting season (BLM 2006h).

Portions of eastern Utah within the PEIS study area are undergoing intensive oil and gas development, and traffic has both changed in character and increased markedly. As was mentioned for Colorado, well drilling and pipeline construction equipment and construction and production traffic utilize these roads throughout the day. County roads that were originally designed for lower traffic levels and for rural and agricultural uses were not intended for heavy loads and traffic volumes associated with oil and gas construction and production. The increasing traffic volume, frequency, and vehicle size on these roads have contributed to an increase in the costs associated with repair and maintenance. Although constructed to higher standards and for heavier uses, state highways are also subject to these higher traffic volumes and the concomitant need for increased levels of maintenance and repair.

3.11.4.3 Wyoming

I-80 traverses the central part of the Green River Basin and crosses the northern edge of the Washakie Basin in Wyoming and provides primary access to the oil shale resources in these areas. Additional major roads passing through or near the Green River Basin are U.S. Highways 30, 189, and 191. Other major roads in the Green River Basin are Highways 28, 240, 372, 410, 412, 414, and 530. The north–south Highways 430 and 789 also provide access to the Washakie Basin. Numerous other local roads occur in the oil shale resource areas, many of which are gravel or dirt and are used primarily by recreationists, local ranchers, and oil and gas operators. Increases in road use associated with oil and gas development are having effects similar to those described above for Colorado and Utah.

3.12 ENVIRONMENTAL JUSTICE

E.O. 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," (U.S. President 1994) formally requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs agencies to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

The analysis of the impacts of oil shale and tar sands development on environmental justice issues follows guidelines described in the CEQ's *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997). The analysis has three parts: (1) a description of the geographic distribution of low-income and minority populations in the affected area; (2) an assessment of whether construction and operation would produce impacts that are high and adverse; and (3) if impacts are high and adverse, a determination as to whether these impacts disproportionately affect minority and low-income populations.

The analysis of environmental justice issues considers impacts at the state level in the three states—Colorado, Utah, and Wyoming. A 50-mi buffer was used to capture the effects of oil shale and tar sands development construction and operation that may occur beyond designated land.

The description of the geographic distribution of minority and low-income groups is based on demographic data from the 2010 Census (U.S. Census Bureau 2012). The following definitions were used to define minority and low-income population groups:

- **Minority.** Persons are included in the minority category if they identify themselves as belonging to any of the following racial groups: (1) Hispanic or Latino, (2) Black (not of Hispanic or Latino origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or Other Pacific Islander.

  Beginning with the 2010 Census, where appropriate, the census form allows individuals to designate multiple population group categories to reflect their ethnic or racial origins. In addition, persons who classify themselves as being of multiple racial origins may choose up to six racial groups as the basis of their racial origins. The term *minority* includes all persons, including those classifying themselves in multiple racial categories, except those who classify themselves as not of Hispanic or Latino origin and as White or "Other Race" (U.S. Census Bureau 2007).

  The CEQ guidance proposed that minority populations should be identified where either (1) the minority population of the affected area exceeds 50%, or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

  In this PEIS, both criteria were applied in using the Census Bureau data for census block groups; consideration was given to the minority population that is both more than 50% and 20 percentage points higher than in the state (the reference geographic unit).

- **Low Income.** Individuals who fall below the poverty line are included in this category. The poverty line takes into account family size and age of individuals in the family. In 2009, for example, the poverty line for a family of five with three children below the age of 18 was $25,790. For any family below the poverty line, all family members are considered to be below the poverty line for the purposes of analysis (U.S. Bureau of Census 2012).

  The CEQ guidance proposed that low-income populations should be identified where either (1) the low-income population of the affected area exceeds 50%, or (2) the low-income population percentage of the affected area is meaningfully greater than the low-income population percentage in the general population or other appropriate unit of geographic analysis.

  In this PEIS, both criteria were applied in using the Census Bureau data for census block groups; consideration was given to the low-income population that is both more than 50% and 20 percentage points higher than in the state (the reference geographic unit).

Data in Tables 3.12-1 and 3.12-2 show the minority and low-income composition of total population located in the designated oil shale and tar sands development areas and associated 50-mi buffers in the three states (based on 2010 Census data and CEQ Guidelines). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics or Latinos can be of any race, this number also includes individuals who identify themselves as being part of one or more of the population groups listed in the table.

On the basis of 2010 Census data, low-income and minority populations are located in each of the three states where oil shale and tar sands development may occur (Figures 3.12-1 through 3.12-4).

In Utah, there are six census block groups within 50 mi of the oil shale area where the minority population exceeds 50% of the total population in each block group; there are two block

TABLE 3.12-1 Minority and Low-Income Populations in the Oil Shale Resource Area and Buffer

Population Segment	Colorado Block Groups	Idaho Block Groups	Utah Block Groups	Wyoming Block Groups
Total population	297,251	1,034	134,291	89,496
White, non-Hispanic	240,205	969	114,105	75,966
Hispanic or Latino	47,215	43	10,861	10,005
Non-Hispanic or Latino minorities	9,831	22	9,325	3,525
One race	5,754	14	7,228	2,366
Black or African American	1,404	0	382	562
American Indian or Alaskan Native	1,732	7	5,944	1,179
Asian	2,042	6	590	498
Native Hawaiian or other Pacific Islander	257	1	239	81
Some other race	319	0	73	46
Two or more races	4,077	8	2,097	1,159
Total minority	57,046	65	20,186	13,530
Low-income	10,705	51	4,539	6,953
Minority				
ROI	19.2	6.3	15.0	15.1
State	30.0	16.0	19.6	14.1
Low-income				
ROI	9.7	14.0	10.8	9.2
State	12.2	13.6	10.8	9.8

TABLE 3.12-2 Minority and Low-Income Populations in the Tar Sands Resource Area and Buffer

Population Segment	Colorado Block Groups	Utah Block Groups	Wyoming Block Groups
Total population	147,989	362,864	3,867
White, non-Hispanic	122,742	300,305	3,461
Hispanic or Latino	19,925	37,219	283
Non-Hispanic or Latino minorities	5,322	25,340	123
One race	3,065	19,393	72
Black or African American	790	1,392	13
American Indian or Alaskan Native	923	12,398	30
Asian	1,071	3,510	19
Native Hawaiian or other Pacific Islander	142	1,719	10
Some other race	139	374	0
Two or more races	2,257	5,947	51
Total minority	25,247	62,559	406
Low-income	6,203	15,849	120
Minority			
ROI	17.1	17.2	10.5
State	30.0	19.6	14.1
Low-income			
ROI	11.3	15.6	3.6
State	12.2	10.8	9.8

Source: U.S. Census Bureau (2012).

groups where the minority share of the total block group population exceeds the state average by more than 20 percentage points. This minority population is located in the northeastern part of the state in the immediate vicinity of the oil shale resource area itself, that is, in the southeastern portion of the Uintah and Ouray Indian Reservation, and in the north-central part of the state, to the east of Springville. Five census block groups within 50 mi of the oil shale area exceed the state percent low-income by more than 20 percentage points; one block group has more than 50% low-income. The low-income population is centered in roughly the same area as the minority population, with five block groups in the southeastern portion of the Uintah and Ouray Indian Reservation, and one located in the vicinity of Price.

Within 50 mi of the oil shale area in Colorado, there is one census block group that has a minority population exceeding 50% of the total population; it is located to the east of the oil shale area, in Carbondale. Two census block groups with a low-income population that exceeds

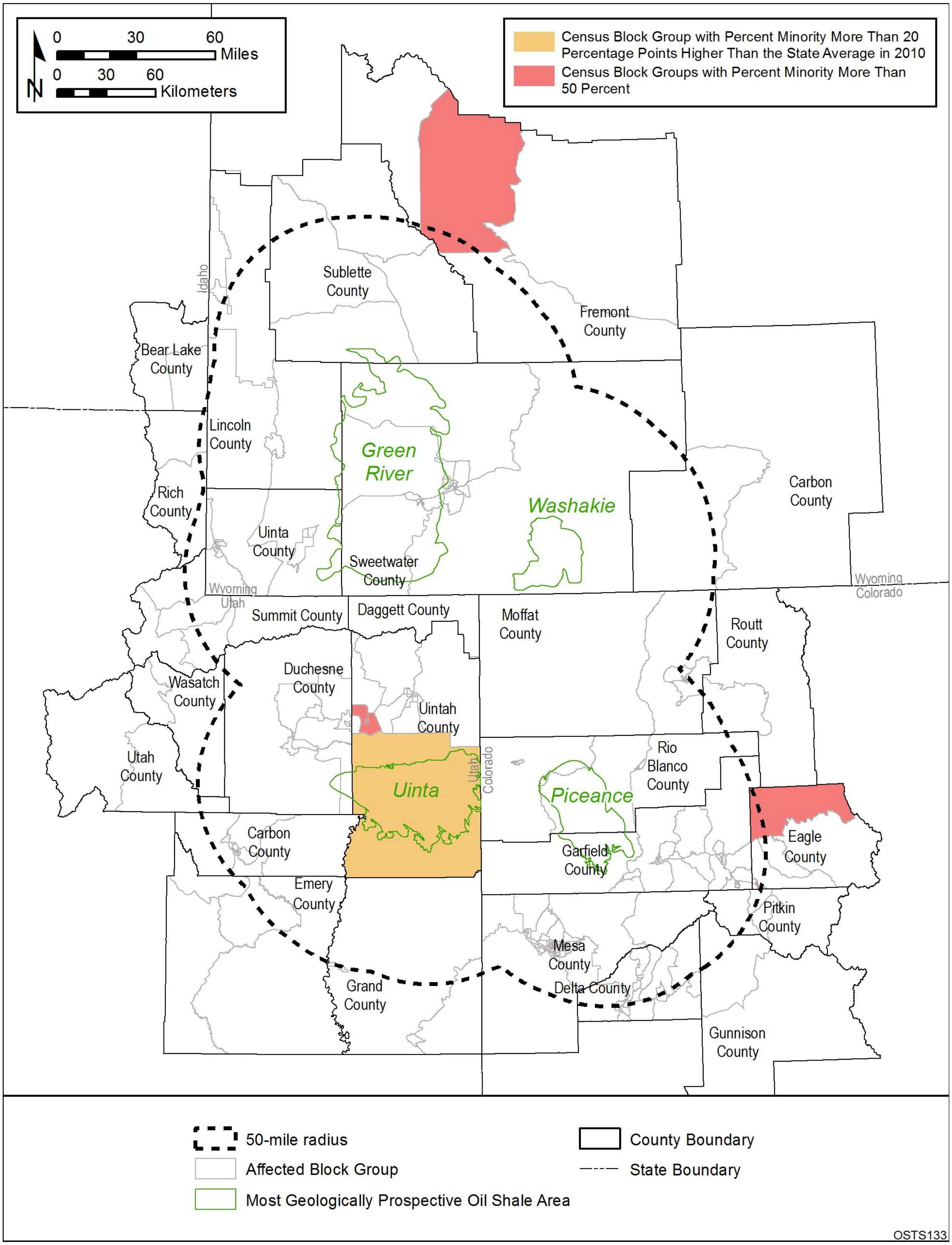

FIGURE 3.12-1 Minority Population Concentration in Census Block Groups within Oil Shale Resource Areas and Associated 80-km (50-mi) Buffer

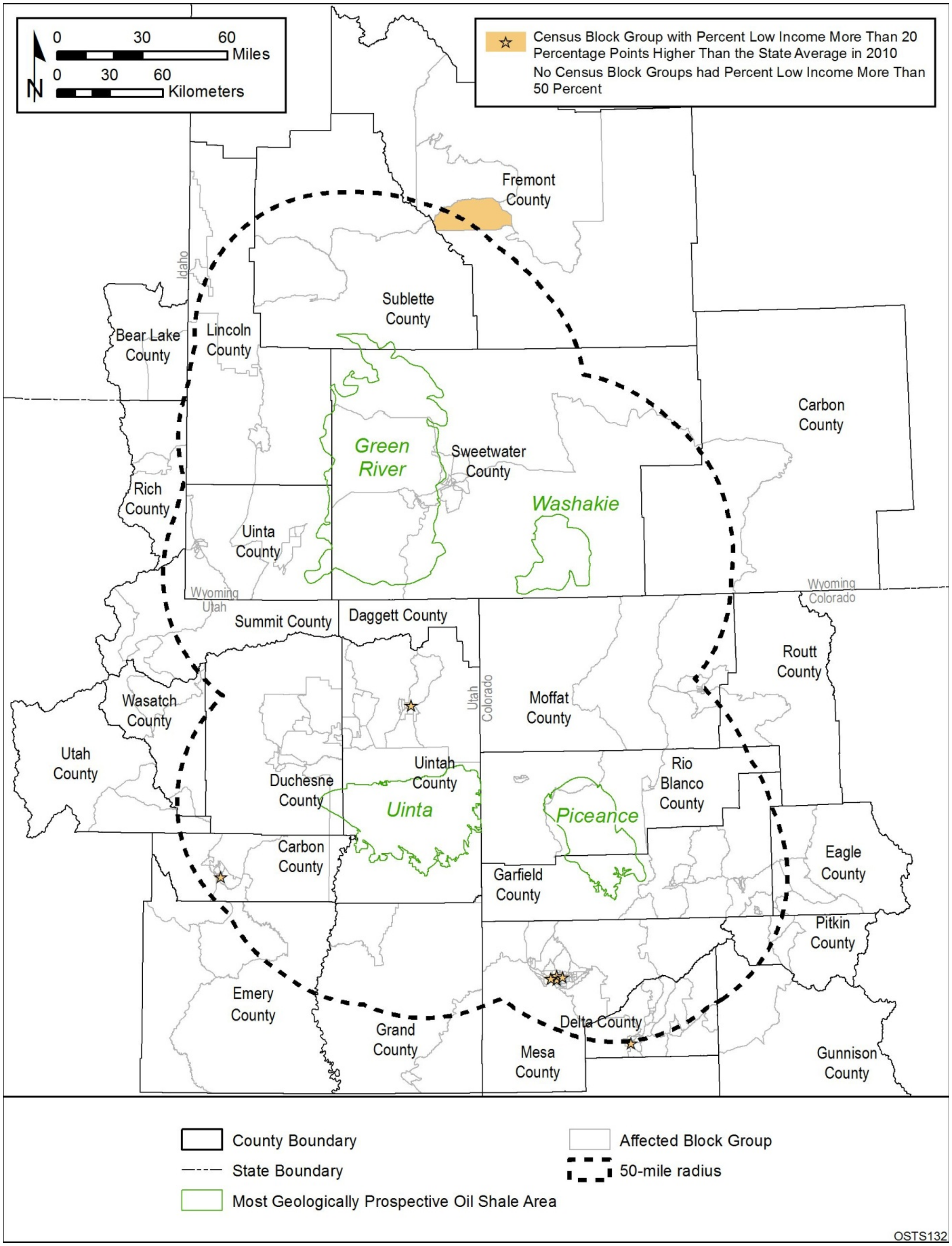

FIGURE 3.12-2 Low-Income Population Concentration in Census Block Groups within Oil Shale Resource Areas and Associated 80-km (50-mi) Buffer

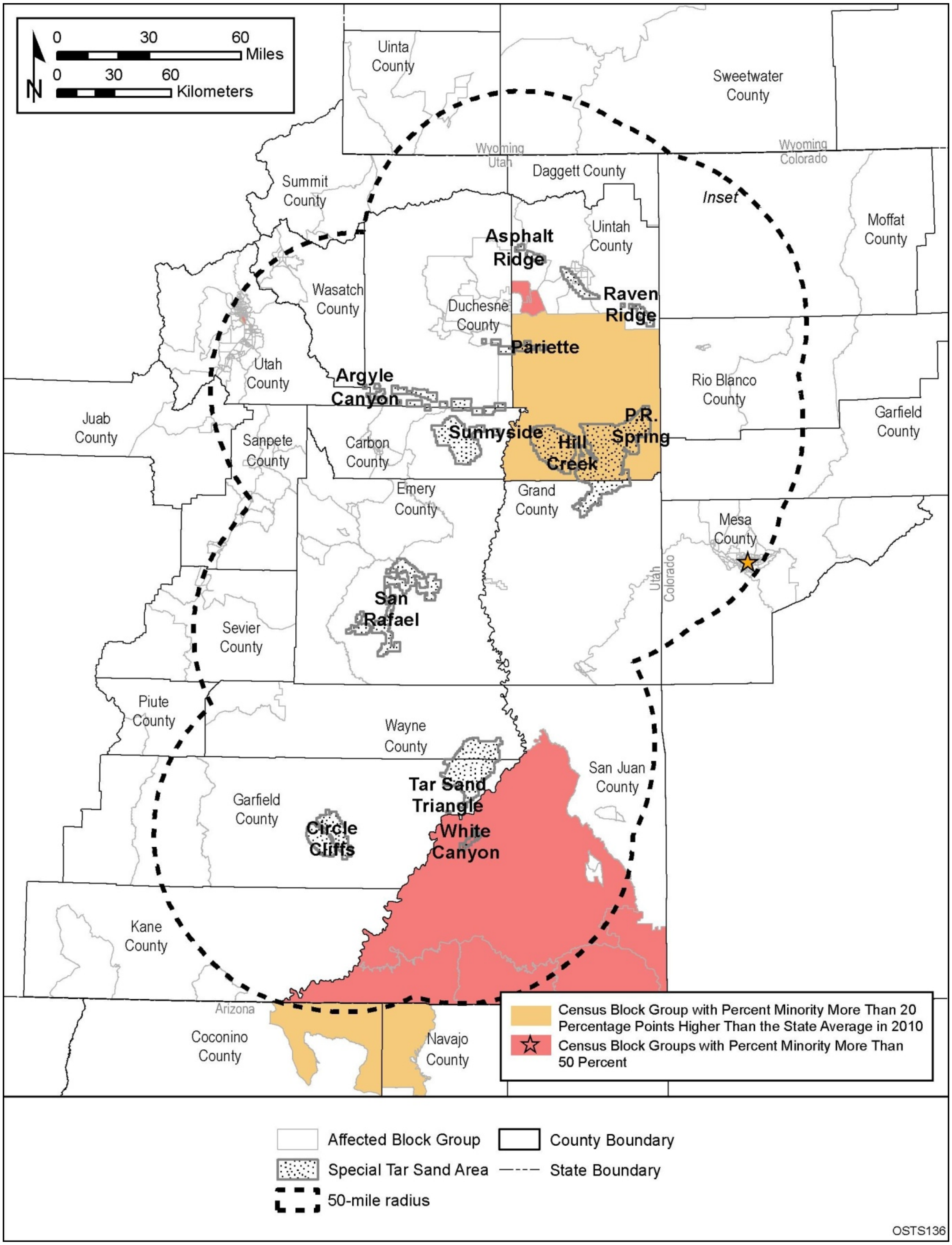

FIGURE 3.12-3 Minority Population Concentration in Census Block Groups within Tar Sands Resource Areas and Associated 80-km (50 mi) Buffer

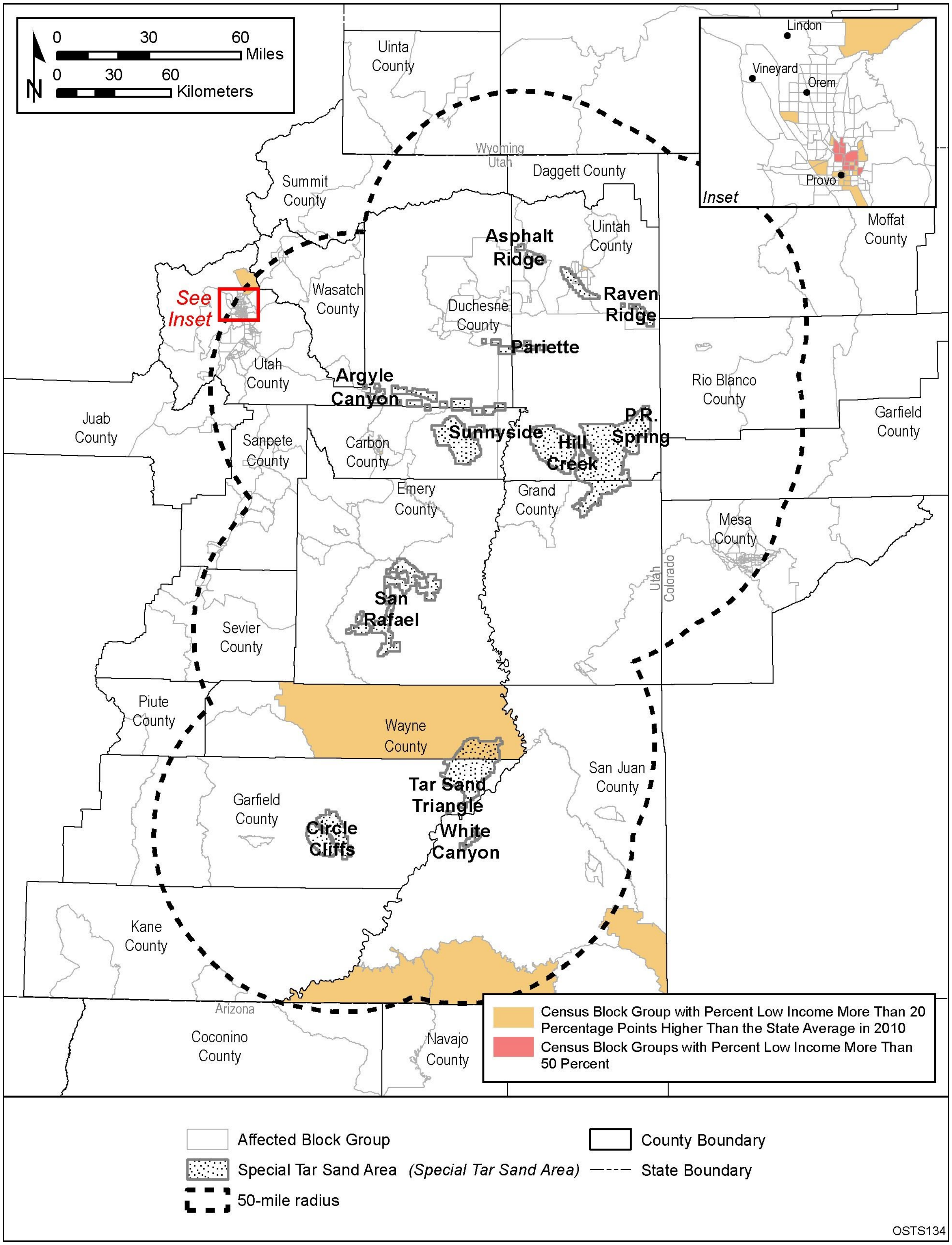

FIGURE 3.12-4 Low-Income Population Concentration in Census Block Groups within Tar Sands Resource Areas and Associated 80-km (50 mi) Buffer

the state average by more than 20 percentage points are located in Grand Junction. In Wyoming, there are two census block groups located in the Wind River Indian Reservation with a minority population that is more than 50% minority. One census block group with a low-income population exceeding the state average by more than 20 percentage points is also located in the Wind River Indian Reservation.

Fourteen census block groups occur within 50 mi of the tar sands resource areas in Utah where the minority population exceeds 50% of the total population in each block group, and four block groups where the minority share of the total block group population exceeds the state average by more than 20 percentage points. These block groups are located in two separate areas in the state. In the northeastern part of the state, the minority population within 50 mi of the tar sands area is located in the southeastern portion of the Uintah and Ouray Indian Reservation, and in the north-central part of the state to the east of Springville and in Provo. In the southeastern part of the state, the minority population is located to the south of the Tar Sand Triangle and White Canyon areas and includes Blanding and the Navajo and Ute Mountain Indian Reservations. Within 50 mi of the tar sands resource areas in Utah, there are 32 block groups exceeding the state percent low-income by more than 20 percentage points; in Colorado there are 2. There are 18 block groups in Utah where the low-income population is more than 50% of the total population. These groups are centered in much the same area as the minority population, that is, in the southeastern portion of the Uintah and Ouray Indian Reservation, in the north-central part of the state to the east of Springville and in Provo, and in the area to the south of Tar Sand Triangle.

3.13 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained. It is likely that at the time of publication of this PEIS, some of these Web pages may no longer be available or their URL addresses may have changed.

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