DES 12-01

BLM

Draft Programmatic Environmental Impact Statement and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the Bureau of Land Management in Colorado, Utah, and Wyoming

January 2012

Volume 1: Chapters 1, 2, & 3

Draft Programmatic Environmental Impact Statement and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the Bureau of Land Management in Colorado, Utah, and Wyoming

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January 2012 – *Volume 1: Chapters 1, 2, & 3*

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
Washington, D.C. 20240
http://www.blm.gov

TAKE PRIDE IN AMERICA

January 27, 2012

Dear Reader:

In 2008, the Bureau of Land Management (BLM) amended eight land use plans in Colorado, Utah, and Wyoming to make public lands available for potential leasing and development of oil shale resources, and two other land use plans to expand the acreage available for potential tar sands leasing in Utah, where these resources are located. These 2008 Amendments, supported by the preparation of a Programmatic Environmental Impact (PEIS) Statement required under Section 369(d)(1) of the Energy Policy Act of 2005, made approximately 2,000,000 acres available for potential development of oil shale resources and 431,000 acres available for potential development of tar sands resources. The 2008 PEIS and Record of Decision (ROD) amending the land use plans are available at http://ostseis.anl.gov, which includes maps and more specific information about the geographic area studied in 2008.

The BLM has decided to take a fresh look at the land use plan allocation decisions made in the 2008 ROD associated with the PEIS in order to reconsider which lands should be open to future leasing of oil shale and tar sands resources. The purpose and need for the proposed planning action is to reassess the appropriate mix of allowable uses with respect to oil shale and tar sands leasing and potential development.

Attached for your review and comment is the *Draft Resource Management Plan (RMP) Amendments and Draft PEIS for the Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the BLM in Colorado, Utah, and Wyoming.* The BLM prepared this document in consultation with cooperating agencies and in accordance with the National Environmental Policy Act of 1969, the Federal Land Policy and Management Act of 1976, implementing regulations, the BLM *Land Use Planning Handbook* (H-1610-1), and other applicable laws. The *Draft RMP Amendments and Draft PEIS* and supporting information are also available on the project Web site at http://osts.eis.anl.gov.

This PEIS examines alternatives for making BLM-administered lands available for application for future commercial leasing of both oil shale and tar sands resources. The study area for the oil shale resources includes the most geologically prospective resources of the Green River Formation located in the Piceance, Uinta, Green River, and Washakie Basins. The oil shale planning area consists of about 3,538,038 acres, which includes 2,138,361 acres of public lands and 158,566 acres of split estate lands.

The study area for tar sands includes those locations designated as Special Tar Sands Areas in the geologic reports prepared by the United States Geological Survey in 1980 and formalized by Congress in the Combined Hydrocarbon Leasing Act of 1981 (P.L. 97-78). The tar sands planning area consists of about 1,026,266 acres of land, which includes about 574,357 acres of public lands and 82,148 acres of split estate lands.

The BLM encourages the public to provide information and comments pertaining to the analysis presented in the *Draft RMP Amendments and Draft PEIS*. Of particular importance is feedback concerning the adequacy and accuracy of the proposed alternatives, the analysis of their respective management decisions, and any new information that would help the BLM produce a Proposed Plan. In developing the Proposed RMP/Final PEIS, which is the next phase of the planning process, the decisionmaker may select various management decisions from each of the alternatives analyzed in the Draft RMP/PEIS to create a management strategy that best meets the needs of the resources and values in this area under the multiple-use and sustained-yield mandate. As a member of the public, your timely comments will help formulate the Proposed RMP/Final PEIS. The BLM will accept comments for 90 calendar days following the U.S. Environmental Protection Agency's publication of its *Notice of Availability* of the document in the *Federal Register*. The BLM can best utilize your comments and resource information submissions if received during the review period.

Comments may be submitted electronically at http://ostseis.anl.gov/involve/comments/index .cfm. A comment form can be found online at this site. Comments may also be submitted by mail to BLM Oil Shale and Tar Sands PEIS, Argonne National Laboratory, EVS Division, Building 240, 9700 South Cass Avenue, Argonne, Illinois 60439. To facilitate analysis of comments and information submitted, we strongly encourage you to submit comments in electronic format.

Your review and comments on the content of this document are critical to the success of this planning effort. If you wish to submit comments on the Draft RMP/PEIS, we suggest that you make them as specific as possible. Comments will be more helpful if they include suggested changes, sources, or methodologies, and reference a section or page number. The BLM will consider comments containing only opinions or preferences and include them as part of the decision-making process; although, they will not receive a formal response from the BLM.

Before including your address, phone number, email address, or other personal identifying information, you should be aware your entire comment, including your personal identifying information, may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

We will schedule Public Open Houses to provide the public an overview of the document and responses to any questions about the PEIS. We will announce the meetings through the public media in the near future and on the BLM Web site at http://osts.eis.anl.gov.

Copies of the Draft RMP/PEIS have been sent to affected Federal, state, and local government agencies. Copies of the Draft RMP/PEIS are available for public inspection at the following BLM locations:

- Colorado State Office, 2850 Youngfield Street, Lakewood, Colorado 80215;
- Northwest District Office, 2815 H Road, Grand Junction, Colorado 81506;
- Colorado River Valley Field Office, 2300 River Frontage Road, Silt, Colorado 81652;
- Grand Junction Field Office, 2815 H Road, Grand Junction, Colorado 81506;
- White River Field Office, 220 East Market Street, Meeker, Colorado 81641;
- Utah State Office, 440 West 200 South, Suite 500, Salt Lake City, Utah 84101;
- Green River District Office, 170 South 500 East, Vernal, Utah 84078;
- Vernal Field Office, 170 South 500 East, Vernal, Utah 84078;
- Price Field Office, 125 South 600 West, Price, Utah 84501;
- Color Country District Office, 176 East D.L. Sargent Drive, Cedar City, Utah 84721;
- Richfield Field Office, 150 East 900 North, Richfield, Utah 84701;
- Canyon Country District Office, 82 East Dogwood, Moab, Utah 84532;
- Monticello Field Office, 365 North Main, Monticello, Utah 84535;
- Wyoming State Office, 5353 Yellowstone Road, Cheyenne, Wyoming 82009;
- High Desert District Office, 280 Highway 191 North, Rock Springs, Wyoming 82901;
- Rock Springs Field Office, 280 Highway 191 North, Rock Springs, Wyoming 82901;
- Kemmerer Field Office, 312 Highway 189 North, Kemmerer, Wyoming 83101; and
- Rawlins Field Office, 1300 North Third, Rawlins, Wyoming 82301.

Thank you for your continued interest in the *Draft Resource Management Plan (RMP) Amendments and a Draft Programmatic Environmental Impact Statement (PEIS) for the Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the BLM in Colorado, Utah, and Wyoming.* We appreciate the information and suggestions you have contributed to the planning process.

For additional information or clarification regarding this document or the planning process, please contact Sherri Thompson, Project Manager, Bureau of Land Management, Colorado State Office, 2850 Youngfield Street, Lakewood, Colorado 80215-7093, or visit the Web site at http://osts.eis.anl.gov.

Sincerely,

Michael D. Nedd
Assistant Director
Minerals and Realty Management

DES 12-01

Draft Programmatic Environmental Impact Statement and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the Bureau of Land Management in Colorado, Utah, and Wyoming

January 2012

Volume 1: Chapters 1, 2, & 3

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

MISSION STATEMENT

It is the mission of the Bureau of Land Management (BLM), an agency of the Department of the Interior, to manage BLM-administered lands and resources in a manner that best serves the needs of the American people. Management is based upon the principles of multiple use and sustained yield taking into account the long-term needs of future generations for renewable and nonrenewable resources.

BLM-WO-GI-08-005-3900

DOI No. DES 12-01

Draft Programmatic Environmental Impact Statement and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the Bureau of Land Management in Colorado, Utah, and Wyoming

Lead Agency: U.S. Department of the Interior, Bureau of Land Management

Cooperating Agencies:

National Park Service
U.S. Fish and Wildlife Service
State of Utah
State of Wyoming
City of Rifle, Colorado
Grand County, Utah
State of Colorado, Department of Natural Resources and Department of Health and the Environment
Garfield County, Colorado
Duchesne County, Utah
Carbon County, Utah
Uintah County, Utah
Lincoln County, Wyoming
Sweetwater County, Wyoming
Coalition of Local Governments

Location: Northwestern Colorado, Eastern Utah, and Southwestern Wyoming

Abstract: The Bureau of Land Management (BLM) proposes to amend 10 land use plans in Colorado, Utah, and Wyoming to describe those areas that will be open and those that will be closed to application for commercial leasing, exploration, and development of oil shale and tar sands resources. There are approximately 2.3 million acres of BLM-administered lands within this area that are the subject of this programmatic environmental impact statement (PEIS). The Programmatic EIS analyzes four alternatives in detail for allocation of oil shale (two of these include subalternatives), and four analogous alternatives for allocation of tar sands. The BLM has selected Alternative 2(b) as the Preferred Alternative. The Preferred Alternative would make approximately 461,965 acres available for future consideration for commercial oil shale leasing and 91,045 acres available for application for commercial tar sands leasing, but only for research, development, and demonstration (RD&D) leases. The BLM would issue a commercial lease only when a lessee satisfies the conditions of its RD&D lease and the regulations at 43 CFR Subpart 3926 for conversion to a commercial lease. The preference right acreage, if any, which would be included in the converted lease, would be specified in the RD&D lease. Alternative 1, the No Action Alternative, would not amend land use plans. The lands available for lease under the 2008 land use plan amendment decisions would remain available for future leasing consideration. Alternative 2(a) would exclude certain lands from leasing and would amend 10 land use plans in Colorado, Utah, and Wyoming to make approximately 461,965 acres available for future consideration for commercial oil shale leasing and 91,045 acres available for application for commercial tar sands leasing. Alternative 3 would amend 10 land use plans in Colorado, Utah, and Wyoming to limit public lands available for commercial leasing to the those lands encompassed by existing oil shale RD&D leases and their associated preference right lease acreage, plus the areas encompassed by the three RD&D lease applications currently under review. Under this alternative, 32,640 acres would be open for potential future leasing of oil shale. For the tar sands resources under Alternative 3, the lands identified as available for application for commercial leasing would be limited to those lands in the Vernal, Utah, planning area, for which there is a pending tar sands lease application (approximately. 2,100 acres). Alternative 4(a) would exclude certain lands from commercial oil shale or tar sands leasing, similar to Alternative 2 and would amend 10 land use plans in Colorado, Utah, and Wyoming to designate acreage less than 2,017,714 acres as available for future consideration for leasing for commercial oil shale leasing and less than 430,686 acres as available for application for commercial tar sands leasing. Alternative 4(b) would open the same acreage as those lands opened in Alternative 4(a) but only for RD&D leases. The BLM

would issue a commercial lease only when a lessee satisfies the conditions of its RD&D lease and the regulations at 43 CFR Subpart 3926 for conversion to a commercial lease. The preference right acreage, if any, which would be included in the converted lease, would be specified in the RD&D lease. This PEIS has been developed to analyze the direct, indirect, and cumulative environmental, cultural, and socioeconomic impacts of the four alternatives. While the BLM has determined that there are no environmental impacts associated with the amendment of land use plans, it is intending to establish a commercial leasing program to facilitate future development and has included a programmatic-level analysis of the potential impact of oil shale and tar sands development technologies as they are currently known.

Contacts: For further information about this PEIS, you may contact Sherri Thompson, Project Manager, BLM Colorado State Office, 2850 Youngfield Street, Lakewood, Colorado 80215-7093; (303) 239-3758.

Comments: The public will have 90 days to review and comment on the document from the date the U.S. Environmental Protection Agency files the Notice of Availability for the PEIS in the *Federal Register*. For the most recent information on document filing status, or for additional information regarding the PEIS, please see the project Web site at http://ostseis.anl.gov.

Responsible Official:

Michael Nedd
BLM Assistant Director,
Minerals, Realty and Resource Protection
1849 "C" Street N.W.
Washington, D.C. 20240

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NOTATION

The following is a list of acronyms and abbreviations, chemical names, and units of measure used in this document. Some acronyms used only in tables may be defined only in those tables.

GENERAL ACRONYMS AND ABBREVIATIONS

ACEC	Area of Critical Environmental Concern
AGFD	Arizona Game and Fish Department
AGR	aboveground retort
AIRFA	American Indian Religious Freedom Act
AMSO	American Shale Oil LLC
ANFO	ammonium nitrate and fuel oil
API	American Petroleum Institute
APLIC	Avian Power Line Interaction Committee
APP	Avian Protection Plan
AQRV	air quality related value
ARCO	Atlantic Richfield Company
ATP	Alberta Taciuk Process
ATSDR	Agency for Toxic Substances and Disease Registry
AWEA	American Wind Energy Association
BA	biological assessment
BCD	barrels per calendar day
BLM	Bureau of Land Management
BMP	best management practice
BO	biological opinion
BOR	U.S. Bureau of Reclamation
BPA	Bonneville Power Administration
BSD	barrels per stream day
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAA	Clean Air Act
CAPP	Canadian Association of Petroleum Producers
CARB	California Air Resources Board
CASTNET	Clean Air Status and Trends NETwork
CBOSC	Cathedral Bluffs Oil Shale Company
CCW	coal combustion waste
CDC	Centers for Disease Control and Prevention
CDOT	Colorado Department of Transportation
CDOW	Colorado Division of Wildlife
CDPHE	Colorado Department of Public Health and Environment
CDW	Colorado Division of Wildlife

CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
CHL	combined hydrocarbon lease
CIRA	Cooperative Institute for Research in the Atmosphere
COGCC	Colorado Oil and Gas Conservation Commission
CPC	Center for Plant Conservation
CRBSCF	Colorado River Basin Salinity Control Forum
CRSCP	Colorado River Salinity Control Program
CWRQIP	Colorado River Water Quality Improvement Program
CSS	cyclic steam stimulation
CSU	Controlled Surface Use
CWA	Clean Water Act
CWCB	Colorado Water Conservation Board
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
DRMS	Division of Reclamation Mining & Safety (Colorado)
EA	environmental assessment
EGL	EGL Resources, Inc.
EIA	Energy Information Administration
E-ICP	bare electrode in situ conversion process
EIS	environmental impact statement
EMF	electric and magnetic field
E.O.	Executive Order
EOR	enhanced oil recovery
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act of 1973
EUB	Alberta Energy and Utilities Board
FAA	Federal Aviation Administration
FLPMA	Federal Land Policy and Management Act of 1976
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FTE	full-time equivalent
FY	fiscal year
GCR	gas combustion retort
GHG	greenhouse gas
GIS	geographic information system
GPO	Government Printing Office

GSENM	Grand Staircase–Escalante National Monument
HAP	hazardous air pollutant
HAZCOM	hazard communication
HFC	hydrofluorcarbon
HMA	Herd Management Area
HMMH	Harris Miller Miller & Hanson, Inc.
I-70	Interstate 70
IARC	International Agency for Research on Cancer
ICP	in situ conversion process
IEC	International Electrochemical Commission
IPPC	Intergovernmental Panel on Climate Change
ISA	Instant Study Area
ISWS	Illinois State Water Survey
IUCNNR	International Union for Conservation of Nature and Natural Resources
JMH CAP	Jack Morrow Hills Coordinated Activity Plan
KOP	key observation point
KSLA	Known Sodium Leasing Area
LAU	Lynx Analysis Unit
LETC	Laramie Energy Technology Center
LPG	liquefied petroleum gas
L_{dn}	day-night average sound level
L_{eq}	equivalent sound pressure level
LWC	lands having wilderness characteristics
M&I	municipal and industrial
MFP	Management Framework Plan
MIS	modified in situ recovery
MLA	Mineral Leasing Act
MMC	Multi Minerals Corporation
MMTA	Mechanically Mineable Trona Area
MOU	Memorandum of Understanding
MPCA	Minnesota Pollution Control Agency
MSDS	Material Safety Data Sheet
MSHA	Mine Safety and Health Administration
MSL	mean sea level
MTR	military training route
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NAGPRA	Native American Graves Protection and Repatriation Act
NCA	National Conservation Area

NCDC	National Climate Data Center
NEC	National Electric Code
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act of 1966
NFS	National Forest Service
NLCS	National Landscape Conservation System
NMFS	National Marine Fisheries Service
NNHP	Nevada Natural Heritage Program
NOI	Notice of Intent
NORM	naturally occurring radioactive materials
NOSR	Naval Oil Shale Reserves
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRA	National Recreation Area
NRHP	*National Register of Historic Places*
NSC	National Safety Council
NSO	No Surface Occupancy
NWCC	National Wind Coordinating Committee
OHV	off-highway vehicle
OOSI	Occidental Oil Shale, Inc.
OPEC	Organization of Petroleum Exporting Countries
OSEC	Oil Shale Exploration Company
OSEW/SPP	Oil Sands Expert Workgroup/Security and Prosperity Partnership
OSHA	Occupational Safety and Health Administration
OSTS	oil shale and tar sands
OTA	Office of Technology Assessment
PA	Programmatic Agreement
PADD	Petroleum Administration for Defense District
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEIS	programmatic environmental impact statement
PFC	perfluorcarbons
PFYC	Potential Fossil Yield Classification
P.L.	Public Law
PM	particulate matter
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 μm or less
PM_{10}	particulate matter with an aerodynamic diameter of 10 μm or less
PPE	personal protective equipment
PRLA	preference right lease area
PSD	Prevention of Significant Deterioration
R&D	research and development
R&I	relevance and importance
RBOSC	Rio Blanco Oil Shale Company

RCRA	Resource Conservation and Recovery Act of 1976
RD&D	research, development, and demonstration
RF	radio frequency
RFDS	reasonably foreseeable development scenario
RMP	Resource Management Plan
ROD	Record of Decision
ROI	region of influence
ROS	Recreation Opportunity Spectrum
ROW	right-of-way
SAGD	steam-assisted gravity drainage
SAMHSA	Substance Abuse and Mental Health Services Administration
SDWA	Safe Drinking Water Act of 1974
SFC	Synthetic Fuels Corporation
SHPO	State Historic Preservation Office(r)
SIP	State Implementation Plan
SMA	Special Management Area
SMP	suggested management practice
SPR	Strategic Petroleum Reserve
SRMA	Special Recreation Management Area
SSI	self-supplied industry
STSA	Special Tar Sand Area
SWCA	SWCA, Inc., Environmental Consultants
SWPPP	Stormwater Pollution Prevention Plan
SWWRC	States West Water Resources Corporation
TDS	total dissolved solids
THAI	toe to head air injection
TIS	true in situ recovery
TL	timing limitation
TMDL	Total Maximum Daily Load
TOSCO	The Oil Shale Corporation
TSCA	Toxic Substances Control Act of 1976
TSDF	treatment, storage, and disposal facility
UDEQ	Utah Department of Environmental Quality
UDNR	Utah Department of Natural Resources
UDWR	Utah Division of Wildlife Resources
UIC	underground injection control
USACE	U.S. Army Corps of Engineers
USC	*United States Code*
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey

VCRS	Visual Contrast Rating System
VOC	volatile organic compound
VRI	visual resource inventory
VRM	Visual Resource Management
WDEQ	Wyoming Department of Environmental Quality
WGFD	Wyoming Game and Fish Department
WRAP	Western Regional Air Partnership
WRCC	Western Regional Climate Center
WRI	World Resources Institute
WRSOC	White River Shale Oil Corporation
WSA	Wilderness Study Area
WSR	Wild and Scenic River
WTGS	wind turbine generator system
WYCRO	Wyoming Cultural Records Office

CHEMICALS

CH_4	methane	N_2O	nitrous oxides
CO	carbon monoxide	NO_x	nitrogen oxides
CO_2	carbon dioxide	O_3	ozone
CO_{2e}	carbon dioxide equivalent		
		Pb	lead
H_2S	hydrogen sulfide		
		SF_6	sulfur hexafluoride
NH_3	ammonia	SO_2	sulfur dioxide
NO_2	nitrogen dioxide	SO_x	sulfur oxides

UNITS OF MEASURE

ac-ft	acre foot (feet)	ft^3	cubic foot (feet)
bbl	barrel(s)	g	gram(s)
Btu	British thermal unit(s)	gal	gallon(s)
		GJ	gigajoule(s)
°C	degree(s) Celsius	gpd	gallon(s) per day
cfs	cubic foot (feet) per second	gpm	gallon(s) per minute
cm	centimeter(s)	GW	gigawatt(s)
		GWh	gigawatt hour(s)
dB	decibel(s)		
dBA	A-weighted decibel(s)	h	hour(s)
		ha	hectare(s)
°F	degree(s) Fahrenheit	hp	horsepower
ft	foot (feet)	Hz	hertz

in.	inch(es)
K	degree(s) Kelvin
kcal	kilocalorie(s)
kg	kilogram(s)
km	kilometer(s)
kPa	kilopascal(s)
kV	kilovolt(s)
kWh	kilowatt-hour(s)
L	liter(s)
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mg	milligram(s)
mi	mile(s)
mi^2	square mile(s)
mm	millimeter(s)
MMBtu	thousand Btu
mph	mile(s) per hour
MW	megawatt(s)
ppb	part(s) per billion
ppm	part(s) per million
ppmv	part(s) per million by volume
psi	pound(s) per square inch
rpm	rotation(s) per minute
s	second(s)
scf	standard cubic foot (feet)
yd^2	square yard(s)
yd^3	cubic yard(s)
yr	year(s)
µm	micrometer(s)

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ENGLISH/METRIC AND METRIC/ENGLISH EQUIVALENTS[a]

The following table lists the appropriate equivalents for English and metric units.

Multiply	By	To Obtain
English/Metric Equivalents		
acres	0.4047	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
degrees Fahrenheit (ºF) –32	0.5555	degrees Celsius (ºC)
Feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (L)
gallons (gal)	0.003785	cubic meters (m^3)
inches (in.)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
miles per hour (mph)	1.609	kilometers per hour (kph)
pounds (lb)	0.4536	kilograms (kg)
short tons (tons)	907.2	kilograms (kg)
short tons (tons)	0.9072	metric tons (t)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
yards (yd)	0.9144	meters (m)
Metric/English Equivalents		
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
cubic meters (m^3)	264.2	gallons (gal)
degrees Celsius (ºC) +17.78	1.8	degrees Fahrenheit (ºF)
hectares (ha)	2.471	acres
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	short tons (tons)
kilometers (km)	0.6214	miles (mi)
kilometers per hour (kph)	0.6214	miles per hour (mph)
liters (L)	0.2642	gallons (gal)
meters (m)	3.281	feet (ft)
meters (m)	1.094	yards (yd)
metric tons (t)	1.102	short tons (tons)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)

[a] In general in this PEIS, only English units are presented. However, where reference sources provided both English and metric units, both values are presented in the order in which they are given in the source. Where reference sources provided only metric units, only those units are presented.

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EXECUTIVE SUMMARY

ES.1 BACKGROUND TO THE PEIS

In September 2008, pursuant to Section 369 of the Energy Policy Act of 2005, the Federal Land Management Policy Act of 1976 (FLPMA), and the National Environmental Policy Act of 1969 (NEPA), the U.S. Department of the Interior (DOI), Bureau of Land Management (BLM), issued a Proposed Plan Amendments/Final Oil Shale and Tar Sands (OSTS) Programmatic Environmental Impact Statement (PEIS) analyzing the environmental and socioeconomic impacts of amending 12 land use plans in Colorado, Utah, and Wyoming to designate public lands administered by the BLM as available for commercial leasing for oil shale or tar sands development (BLM 2008a).[1] The November 17, 2008, ROD that followed this PEIS adopted the proposed land use amendments reflecting the allocation decisions analyzed in the 2008 OSTS PEIS (BLM 2008b). These land allocation decisions, which are currently in effect, were challenged in a lawsuit brought by a coalition of environmental organizations in January 2009. As part of a settlement agreement entered into by the United States to resolve the lawsuit and in light of new information that has emerged since the 2008 OSTS PEIS was prepared, the BLM has decided to take a fresh look at the land allocations analyzed in the 2008 OSTS PEIS, now covered under 10 land use plans after some consolidation, and to consider excluding certain lands from future leasing of oil shale and tar sands resources. Specifically, the BLM, through its planning process, intends to take a hard look at whether it is appropriate for approximately 2,000,000 acres to remain available for potential development of oil shale and approximately 431,000 acres of public land to remain available for potential development of tar sands.

The BLM proposes to amend 10 land use plans in Colorado, Utah, and Wyoming to describe those areas that will be open and those that will be closed to application for commercial leasing, exploration, and development of oil shale and tar sands resources. The analyses in this PEIS have been developed to evaluate the effects of this proposed action and its alternatives. The current land use plans in the study area describe land allocations analyzed in the 2008 OSTS PEIS and approved in the subsequent ROD (BLM 2008a,b).

As noted above, the BLM has decided to reconsider the 2008 allocations. The purpose and need for this proposed planning action is to reassess the appropriate mix of allowable uses with respect to oil shale and tar sands leasing and potential development. Specifically, the BLM will consider amending the applicable Resource Management Plans (RMPs) to specify whether any areas in Colorado, Utah, and Wyoming currently open for application for future leasing and development of oil shale or tar sands should not be available for such application for leasing and development. The phrase “available for application for leasing” is used throughout the PEIS, rather than simply “available for leasing” to highlight that, unlike the BLM’s practice with respect to oil and gas leasing, additional analysis, including but not limited to NEPA, the

[1] While the 2008 Record of Decision (ROD) amended 12 land use plans, some of these plans were subsequently incorporated into revised plans. Therefore, the study area is now covered by 10 land use plans, which are being considered for amendment in this planning process.

National Historic Preservation Act of 1966 (NHPA), and the Endangered Species Act of 1973 (ESA), would be required prior to the issuance of any lease of oil shale or tar sands.

This Draft PEIS contains analyses of the direct, indirect, and cumulative environmental, cultural, and socioeconomic impacts of the proposed action and alternatives. Preparation of this PEIS complies with the requirements of FLPMA, NEPA, the President's Council on Environmental Quality's (CEQ's) NEPA implementing regulations, the BLM's land use planning regulations contained in Part 1600 of Title 43 of the *Code of Federal Regulations* (43 CFR Part 1600), the BLM's *Land Use Planning Handbook* (H-1601-1) (BLM 2005), and the BLM's *NEPA Handbook* (H-1790-1) (BLM 2008c).

ES.2 DESCRIPTION OF THE PLANNING AREA

The study area for the oil shale resources includes the most geologically prospective area of the Green River Formation located in the Piceance, Uinta, Green River, and Washakie Basins. The BLM identified the most geologically prospective areas for oil shale development on the basis of the grade and thickness of the deposits within the Green River Formation. There are approximately 2.3 million acres of BLM-managed lands within this area that are the subject of this PEIS. For the tar sands resources, the study area, which coincides with the area considered to be the most geologically prospective for tar sands development, includes those locations in Utah previously designated as Special Tar Sand Areas (STSAs) in the geologic reports (minutes) prepared by the U.S. Geological Survey in 1980 (USGS 1980a–k) and formalized by Congress in the Combined Hydrocarbon Leasing Act of 1981 (Public Law 97-78). The STSAs contain approximately 654,000 acres of BLM-managed lands. The PEIS study areas for both oil shale and tar sands include public lands administered by the BLM where the federal government owns both the surface estate and subsurface mineral rights and where the federal government owns the subsurface mineral rights but the surface estate is owned by tribes, states, or private parties (i.e., split estate lands).

ES.3 SCOPING PROCESS

A Notice of Intent (NOI) to prepare a PEIS and possible land use plan amendments for allocation of oil shale and tar sands resources on lands administered by the BLM in Colorado, Utah, and Wyoming was published in the *Federal Register* on April 14, 2011 (BLM 2011). The NOI articulated a preliminary purpose and need for the proposed action of amending land use plans, identified planning criteria, initiated the public scoping process, and invited interested members of the public to provide comments on the scope and objectives of the PEIS, including identification of issues and alternatives that should be considered in the PEIS analyses.

The public was provided with three methods for submitting scoping comments or suggestions on potential resource issues that should be discussed in the OSTS PEIS and used to inform consultation activities:

- Via a public Web site,

- By mail, and

- In person at public scoping meetings.

Public scoping meetings were held at seven locations in April and May of 2011: Salt Lake City, Utah (April 26); Price, Utah (April 27); Vernal, Utah (April 28); Rock Springs, Wyoming (April 29); Rifle, Colorado (May 3); Denver, Colorado (May 4); and Cheyenne, Wyoming (May 5). Meetings were held at 1:00 p.m. and 7:00 p.m. at each location, and a court reporter recorded a transcript for each meeting. At each meeting, the BLM presented background information about the OSTS PEIS and related activities. Presentation materials from these meetings, including slides, are available on the project Web site (http://ostseis.anl.gov).

Approximately 4,663 individuals, organizations, and governmental agencies provided comments or suggestions on the scope of the PEIS. Three of these comments were part of major campaigns, each campaign involving an e-mail attachment containing essentially the same letter for each individual submittal. In total, these campaigns represented an additional 23,860 commentors. Approximately 3,061 comment letters were submitted online; 133 were submitted orally at scoping meetings; and 37 comment letters were submitted by mail. Comments were received from 5 state agency divisions (1 from Utah, 2 from Colorado, and 2 from Wyoming), 4 federal agency offices (1 from the National Park Service, 1 from the U.S. Fish and Wildlife Service, 1 from the U.S. Environmental Protection Agency, and 1 from the U.S. Congressional Task Force on Unconventional Fuels), 14 local government organizations (Colorado: Garfield, Mesa, Pitkin, and Rio Blanco Counties; City of Rifle; Towns of New Castle, Rangely, and Silt; Utah: Carbon and Uintah Counties; Wyoming: Board of Lincoln County Commissioners; Coalition of Local Governments; Rock Springs City Council; and Sweetwater County Board of Commissioners), and more than 80 other organizations (including environmental groups, interest groups, consulting firms, and industry).

More than 392 people registered their attendance at the public meetings in April and May 2011; 133 individuals in attendance provided oral or written comments, or both, during the meetings. Of the remaining scoping comments that were submitted, about 0.1% were submitted by mail and 99% were submitted online.

Comments received by mail originated from five states and the District of Columbia. Approximately 4% of the comments originated from states outside the three-state study area. The comments that originated within the study area were distributed as follows: 81 comments from Colorado, 80 comments from Utah, and 14 comments from Wyoming.

A summary of scoping comments is provided in Section J.3 of Appendix J of this document.

ES.4 COOPERATING AGENCIES

The scope of the *Programmatic Environmental Impact Statement and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered*

by the Bureau of Land Management in Colorado, Utah, and Wyoming is of interest to numerous federal, tribal, state, and local governments. The BLM invited 55 agencies to participate in the preparation of the PEIS as cooperating agencies. Fifteen agencies expressed an interest in participating as cooperating agencies, and Memoranda of Understanding between these agencies and the BLM were established. The following agencies are participating as cooperating agencies in the preparation of this PEIS:

- National Park Service (NPS);
- U.S. Fish and Wildlife Service (USFWS);
- State of Colorado Department of Natural Resources (Colorado DNR) and Department of Public Health and the Environment (CDPHE);
- State of Utah;
- State of Wyoming;
- Garfield County, Colorado;
- City of Rifle, Colorado;
- Carbon County, Utah;
- Duchesne County, Utah;
- Grand County, Utah;
- Uintah County, Utah;
- Lincoln County, Wyoming;
- Sweetwater County, Wyoming; and
- Coalition of Local Governments.

The roles and responsibilities of these cooperating agencies, and the extent of interactions between them and the BLM, are discussed in Chapter 7.

ES.5 BLM'S OIL SHALE AND TAR SANDS LEASING PROGRAM

Under all programmatic oil shale and tar sands alternatives analyzed in this PEIS, land use plans would continue to (under the No Action Alternative) or be amended to (1) identify the most geologically prospective oil shale or tar sands resources within each planning unit, (2) designate lands within the most geologically prospective areas as available or not available

for leasing, and (3) identify any technology restrictions. In addition, the following decisions from the 2008 ROD will be carried forward through this planning process: the requirement for future consultation activities, as well as compliance with all pertinent laws, regulations, and policies, including NEPA, NHPA, and ESA analyses; and the specific decision that the BLM will consider and give priority to the use of land exchanges to facilitate commercial oil shale development pursuant to Section 369(n) of the Energy Policy Act of 2005.

In summary, the PEIS is analyzing an allocation decision, the amendment of 10 existing land use plans to designate certain public lands as open, and certain other lands as closed for application for future oil shale and tar sands leasing.

The BLM anticipates that oil shale development would proceed in a three-step decisionmaking process similar to that used for federal onshore oil and gas: (1) land use planning (i.e., amending RMPs), (2) leasing, and (3) project development. In the present experimental stage of the oil shale and tar sands industries, however, the BLM believes that the stages of NEPA compliance will be different from those used in oil and gas.

If and when applications to lease are received and accepted, the BLM will conduct additional required analyses, including consideration of direct, indirect, and cumulative effects, reasonable alternatives, and possible mitigation measures, as well as assessment of the level of development that may be anticipated. On the basis of that analysis of future lease application(s), the BLM will establish general lease stipulations and best management practices (BMPs) and amend those plans, if necessary. After a lease is authorized, actual development will require additional analysis to address the site-specific conditions of the proposed development and to develop mitigating measures.

ES.6 ALTERNATIVES

ES.6.1 Alternative 1, No Action Alternative, No Change to 2008 Decision, Oil Shale

Under Alternative 1, the No Action Alternative, no existing land use plans would be amended. In 2008, the BLM designated a total of 2,017,714 acres[2] as available for application for commercial oil shale leasing and 430,686 acres available for commercial tar sands leasing (see Figures 2.3.2-1, 2.3.2-2, and 2.3.2-3 for Colorado, Utah, and Wyoming, respectively, in Chapter 2 of this document). The lands available for lease under the 2008 land use plan amendment decisions would remain available for future leasing consideration under the No Action Alternative. These public lands comprise the most geologically prospective oil shale and tar sands areas administered by the BLM, including split estate lands where the federal government owns the mineral rights, but excluding lands that are exempted by statute, regulation, or Executive Order.

[2] This amount includes the total potential research, development, and demonstration (RD&D) lease acreage of 30,720 acres.

ES.6.2 Alternative 1, No Action Alternative, No Change to 2008 Decision, Tar Sands

Under this alternative, no existing land use plans would be amended. In 2008, the BLM designated a total of 430,686 acres as available for applications for commercial tar sands leasing. The lands available for lease under the 2008 land use plan amendment decisions would remain available for future leasing consideration under Alternative 1, no action.

ES.6.3 Alternative 2, Oil Shale Conservation Focus Alternative (2a), and with RD&D First Requirement (2b), Oil Shale

Under this alternative, 10 land use plans in Colorado, Utah, and Wyoming would be amended to designate less than 830,000 acres (acreage opened under Alternative C in the 2008 OSTS PEIS) as available for future commercial oil shale leasing. This alternative would exclude from commercial oil shale leasing the following categories or groups of categories of public lands and/or their resource values that may warrant protection from potential oil shale leasing and development:

1. All areas that the BLM has identified or may identify as a result of inventories conducted during this planning process, as lands having wilderness characteristics (LWC);

2. The whole of the Adobe Town "Very Rare or Uncommon" area, as designated by the Wyoming Environment Quality Council on April 10, 2008 (180,910 acres total; 167,517 acres of public land, of which 10,920 acres are already a BLM Wilderness Study Area [WSA]);

3. Core or priority sage-grouse habitat, as defined by such guidance as the BLM or the DOI may issue;

4. All Areas of Critical Environmental Concern (ACECs) located within the areas analyzed in the 2008 OSTS PEIS (76,666 acres in existing ACECs in the 2008 OSTS PEIS plus additional ACEC acreages as a result of Utah and Wyoming planning efforts recently completed);[3] and

5. All areas identified as excluded from commercial oil shale and tar sands leasing in Alternative C of the September 2008 OSTS PEIS (Alternative C made 830,296 acres available for potential commercial oil shale leasing and 229,038 acres available for potential commercial tar sands leasing).

RD&D First Requirement (2b). Under this alternative, the lands open for future leasing consideration would be the same as those in Alternative 2(a), but only for RD&D leases. The

[3] This would include analysis of excluding from future oil shale and tar sands leasing not only all ACECs, but also areas that had been under consideration for designation as ACECs in the applicable plans undergoing revision or amendment at the time, but which were eventually not designated.

BLM would issue a commercial lease only when a lessee satisfies the conditions of its RD&D lease and the regulations at 43 CFR Subpart 3926 for conversion to a commercial lease. The preference right acreage, if any, which would be included in the converted lease, would be specified in the RD&D lease.

The environmental impacts of Alternative 2(b) would be analytically indistinguishable from those of Alternative 2(a). Only the method of obtaining a lease would be different. Accordingly, the analysis in this PEIS of Alternative 2 applies fully and equally to both alternatives. To the extent there may be differences in environmental consequences between Alternative 2(a) and 2(b), these would be related to the timing of the commencement of impacts, as well as, possibly, length of disturbance. However, these issues are best addressed in the lease and/or project-specific analysis.

ES.6.4 Alternative 2, Conservation Focus Alternative, Tar Sands

Under this alternative, six land use plans in Utah would be amended to designate less than 229,000 acres (acreage opened under Alternative C of the 2008 plan amendment) as available for future commercial tar sands leasing. This alternative would exclude from commercial oil shale leasing the same categories or groups of categories of public lands and/or their resource values as listed above under Alternative 2, Oil Shale.

ES.6.5 Alternative 3, Oil Shale Research Lands Focus (RD&D with PRLA only), Oil Shale

Under Alternative 3, 10 land use plans would be amended such that public lands for commercial leasing would be available only where there were existing RD&D leases at the time the ROD for the 2012 Final OSTS PEIS is signed. The six current RD&D leases contain terms and conditions that could allow commercial development of the original leases and the associated preference right lease area (PRLA) totaling 30,720 acres. Another three potential RD&D leases (two in Colorado and one in Utah) are currently undergoing NEPA analysis. Maximum acreage of these three leases, if approved, would be 1,920 acres, bringing the total acreage to 32,640 acres as available for potential oil shale leasing under this alternative.

ES.6.6 Alternative 3, Pending Commercial Lease, Tar Sands

Because there is no specific “RD&D” program for tar sands, this alternative would also analyze foregoing the leasing of tar sands for the commercial development of fluid mineral resources, entirely, except for one tar sands lease currently under consideration. The Asphalt Ridge tar sands lease application is located approximately 11 mi south of Vernal, Utah, and the expression of commercial leasing interest that forms its basis was submitted on November 16, 2009. This prospective lease is for a commercial tar sands project and covers approximately 2,100 acres.

ES.6.7 Alternative 4, 2008 Moderate Development Alternative (2008 OSTS PEIS ROD minus Adobe Town and ACECs) (4a), and with RD&D First Requirement (4b), Oil Shale

Under Alternative 4, the BLM would amend 10 land use plans in Colorado, Utah, and Wyoming to designate acreage less than 2,017,714 acres as available for future consideration for leasing for commercial oil shale leasing and less than 430,686 acres as available for application for commercial tar sands leasing.[4] This alternative would exclude from commercial oil shale or tar sands leasing:

1. The whole of the Adobe Town "Very Rare or Uncommon" area, as designated by the Wyoming Environment Quality Council on April 10, 2008 (180,910 acres total; 167,517 acres of public land, of which 10,920 acres are already a BLM WSA).

2. All ACECs located within the areas analyzed in the 2008 OSTS PEIS (76,666 acres in existing ACECs in 2008 OSTS PEIS plus additional ACEC acreages as a result of Colorado, Utah, and Wyoming planning efforts recently completed).[5]

RD&D First Requirement (4b). Under this alternative, the lands open for future leasing consideration would be the same as those in Alternative 4(a) but only for RD&D leases. The BLM would issue a commercial lease only when a lessee satisfies the conditions of its RD&D lease and the regulations at 43 CFR Subpart 3926 for conversion to a commercial lease. The preference right acreage, if any, which would be included in the converted lease, would be specified in the RD&D lease.

The environmental impacts of Alternative 4(b) would be analytically indistinguishable from those of Alternative 4(a). Only the method of obtaining a lease would be different. Accordingly, the analysis in this PEIS of Alternative 4 applies fully and equally to both alternatives. To the extent there may be differences in environmental consequences between Alternative 4(a) and 4(b), these would be related to the timing of commencement of impacts, as well as, possibly, length of disturbance. However, these issues are best addressed in the lease and/or project-specific analysis.

ES.6.8 Alternative 4, Tar Sands Moderate Development Alternative (2008 OSTS PEIS ROD minus Adobe Town and ACECs), Tar Sands

Under Alternative 4, the BLM would amend four land use plans in Utah to designate acreage less than 430,686 acres as available for application for commercial tar sands leasing.

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[4] This alternative satisfies the settlement agreement to exclude some, but not all, lands from the application of oil shale and tar sands leasing, in comparison to Alternative 2.

[5] This would only include those ACECs that are formally designated in those plans. ACECs that were proposed but not formally designated in the applicable plans undergoing revision/amendment at that time would be excluded.

This alternative satisfies the settlement agreement to exclude some, but not all, lands from the application of oil shale and tar sands leasing,[6] in comparison to Alternative 2. This alternative would exclude from commercial oil shale or tar sands leasing the same two categories of lands listed above for oil shale Alternative 4. However, no prospective tar sands areas fall with the excluded Adobe Town "Very Rare or Uncommon" area.

ES.7 PREFERRED ALTERNATIVE

At this stage in the planning and NEPA process, the BLM has chosen Alternative 2(b) as the preferred alternative for oil shale, and Alternative 2 as the preferred alternative for tar sands. With respect to oil shale, the BLM would like to maintain focus on RD&D projects, so as to obtain more information about the technological requirements for development of this resource, as well as the environmental implications, before committing to broad-scale commercial development. For instance, the BLM looks forward to gaining a clearer understanding of the implications of development of oil shale for water quality and quantity.

ES.8 ANALYSIS OF THE IMPACTS OF THE PROPOSED PLAN AMENDMENT FOR OIL SHALE AND TAR SANDS

As was the case with the 2008 OSTS PEIS, the scope of the decisionmaking to be supported by the development of this PEIS is limited to an allocation decision. The analysis of potential impacts associated with oil shale and tar sands development in Chapters 4, 5, and 6 is programmatic in character and designed to disclose the potential impacts from future leasing and development, in order to provide the decision maker the available, essential information for making the allocation decision.

ES.9 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.

BLM (Bureau of Land Management), 2005, *Land Use Planning Handbook*, BLM Handbook H-1601-1, Washington, D.C., March.

BLM, 2008a, *Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocation in Colorado, Utah, and Wyoming and Final Programmatic Environmental Impact Statement*, FES 08-32, Sept. Available at http://ostseis.anl.gov/.

[6] This alternative satisfies the settlement agreement to exclude some, but not all, lands from the application of oil shale and tar sands leasing, in comparison to Alternative 2.

BLM, 2008b, *Record of Decision for the Oil Shale and Tar Sands Resources Resource Management Plan Amendments*, Nov. 17.

BLM, 2008c, *National Environmental Policy Act Handbook*, BLM Handbook H-1790-1, Washington, D.C., Jan.

BLM, 2011, "Notice of Intent To Prepare a Programmatic Environmental Impact Statement (EIS) and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the Bureau of Land Management in Colorado, Utah, and Wyoming," *Federal Register* 76:21003–21005.

USGS (U.S. Geological Survey), 1980a, *Argyle Canyon–Willow Creek, Utah Tar Sand Leasing Minutes No. 9*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980b, *Asphalt Ridge–Whiterocks and Vicinity, Utah Tar Sand Leasing Minutes No. 3*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980c, *Circle Cliffs East and West Flanks, Utah Tar Sand Leasing Minutes No. 5*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980d, *Hill Creek, Utah Tar Sand Leasing Minutes No. 6*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980e, *Pariette, Utah Tar Sand Leasing Minutes*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980f, *P.R. Spring, Utah Tar Sand Leasing Minutes*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980g, *Raven Ridge–Rim Rock and Vicinity, Utah Tar Sand Leasing Minutes No. 8*, Minutes of the Mineral Land Evaluation Committee, Nov. 10

USGS, 1980h, *San Rafael Swell, Utah Tar Sand Leasing Minutes No. 7*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980i, *Sunnyside and Vicinity, Utah Tar Sand Leasing Minutes No. 4*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980j, *Tar Sand Triangle, Utah Tar Sand Leasing Minutes No. 2*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980k, *White Canyon, Utah Tar Sand Leasing Minutes No. 11*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

1 INTRODUCTION

The U.S. Department of the Interior (DOI), Bureau of Land Management (BLM), proposes to amend 10 land use plans in Colorado, Utah, and Wyoming, pursuant to the provisions of the Federal Land Policy and Management Act of 1976 as amended (FLPMA) (*United States Code*, Title 43, Section 1701 et seq. [43 USC 1701 et seq.]), and BLM planning regulations at Title 43, Part 1600 of the *Code of Federal Regulations* (43 CFR Part 1600), to designate public lands managed by the BLM as available or not available for application for commercial leasing for oil shale or tar sands development. This programmatic environmental impact statement (PEIS) is being prepared pursuant to Section 102 of the National Environmental Policy Act of 1969 (NEPA) (42 USC 4321 et seq.) to support that land use planning process. Prior to issuance of any commercial leases on lands that may be designated as available for application, the BLM must comply with all pertinent laws, regulations, and policies required to analyze the direct, indirect, and cumulative impacts of the proposed lease(s) for development of oil shale or tar sands resources, including, but not limited to, NEPA, National Historic Preservation Act of 1966 (NHPA), and Endangered Species Act of 1973 (ESA). NEPA analysis and other appropriate review would also be required before approval of a lease and subsequent plan of development on a lease, which would include analysis of particular activities at the specific location where development would occur (see the Oil Shale and Tar Sands Development text box). Appropriate stipulations and mitigation measures would be identified as part of both of these subsequent NEPA analyses.

Allocation

A land use allocation identifies activities and foreseeable development that are allowed, restricted, or excluded for specific areas covered by a land use plan. Lands identified as open to oil shale and tar sands development as a result of the analyses in this PEIS are those lands within which the BLM will accept future lease and subsequent project development applications for review. This land use allocation does not authorize any future lease or development proposal. BLM managers retain authority to approve, modify, or deny future lease and development proposals based on consideration of factors, including, but not limited to, impacts on natural and cultural resources, economic viability, community concerns, and any other pertinent factors. Land use planning decisions may be amended, and nothing in the decision based on this PEIS precludes the option to amend plans in the future.

The BLM administers approximately 245 million acres of public lands and 700 million acres of subsurface mineral estate in the United States. Management of these public lands must be conducted in accordance with the requirements of FLPMA (43 USC 1701 et seq.) and many other public laws. FLPMA requires the BLM to develop land use plans, also called Resource Management Plans (RMPs), to guide the management of the public lands it administers. In order for a commercial leasing program to occur on the public lands, the land use plans for the areas where leasing could occur must provide for such leasing.

In Section 369 of the Energy Policy Act of 2005, Public Law (P.L.) 109-58, also known as the "Oil Shale, Tar Sands, and Other Strategic Unconventional Fuels Act of 2005," Congress declared that oil shale and tar sands (and other unconventional fuels) are strategically important domestic energy resources that should be developed to reduce the nation's growing dependence

Oil Shale and Tar Sands Development

The BLM anticipates that oil shale and tar sands development would proceed in a decisionmaking process with three steps: (1) land use planning, (2) leasing, and (3) approval of a plan of development.

Land Use Planning: This PEIS represents the first step in which lands are allocated as open or closed to oil shale/tar sands development. Lands allocated as open are those within which the Secretary may initiate a call for nominations, to which project proponents may respond by submitting applications to lease lands where they propose to develop specific projects. The current experimental state of the oil shale and tar sands industries does not allow this PEIS to include sufficient specific information or cumulative impact analyses to support future leasing decisions within these allocated lands.

Leasing: Leasing is a federal action subject to all pertinent laws, regulations, and policies including, but not limited to, the requirements of NEPA, NHPA, and ESA. The BLM must also review the technical and economic aspects of any proposal to ensure its viability and must ensure the necessary coordination and consultation with other entities, including other federal agencies, tribes, states, local governments, and the public in its consideration of a lease application. The BLM's consideration of a proposal for an oil shale or tar sands lease must be sufficient to take into account predictable impacts of the action on natural and cultural resources, as well as other potential effects. If and when applications to lease oil shale or tar sands for commercial development are received and accepted by the BLM, it may be necessary to develop a reasonably foreseeable development scenario (RFDS). An RFDS is a critical component for the effects analysis required by NEPA, but the information contained in this PEIS is too speculative to permit adequate RFDSs for future leasing proposals. The analyses conducted as part of the review for a lease application may result in a decision to approve, modify, or deny a lease. The BLM may authorize a lease with stipulations and requirements for best management practices, and may amend local land use plans if necessary.

Project Development: After obtaining a lease, a project proponent must submit an application to approve a plan of development. The plan of development identifies the specifics of the development plan such as location, facilities, and timing. Approval of the plan of development is a federal action subject to all pertinent laws, regulations, and policies, including, but not limited to, the requirements of NEPA, NHPA, and ESA. The BLM must also review plans of development for other factors, including economic and technical viability, and must ensure the appropriate consultation and coordination with other federal agencies, tribes, states, local governments, and the public. It is at this final stage, when the particulars of a project are known, that the BLM requires the most detailed analyses and may condition approval on specific requirements to avoid, minimize, or mitigate adverse impacts on various resources.

on oil from politically and economically unstable foreign sources. In addition, Congress declared that both research- and commercial-scale development of oil shale and tar sands should (1) be conducted in an environmentally sound manner using management practices that will minimize potential impacts, (2) occur with an emphasis on sustainability, and (3) benefit the United States while taking into account concerns of the affected states and communities. To support this declaration of policy, Congress directed the Secretary of the Interior (the "Secretary") to undertake a series of steps, several of which are directly related to the development of a commercial leasing program for oil shale and tar sands. Those steps, contained in paragraphs (d), (e), and (n) of the Act, directed that the Secretary shall:

- "…Complete a programmatic environmental impact statement for a commercial leasing program for oil shale and tar sands resources on public lands, with an emphasis on the most geologically prospective lands in Colorado, Utah, and Wyoming";

- "…Not later than 6 months after completion of the programmatic environmental impact statement…the Secretary shall publish a final regulation establishing such program";

- "…Consult with the Governors of States with significant oil shale and tar sands resources on public lands, representatives of local governments in such States, interested Indian Tribes, and other interested persons, to determine the level of support and interest in the States in the development of tar sands and oil shale resources"; and

- "If the Secretary finds sufficient support and interest exists in a State, the Secretary may conduct a lease sale in that State under the commercial leasing program."

- Land Exchanges – (1) "… To facilitate the recovery of oil shale and tar sands, especially in areas where Federal, State, and private lands are intermingled, the Secretary shall consider the use of land exchanges where appropriate and feasible to consolidate land ownership and mineral interests into manageable areas"; (2) "…identify public lands containing deposits of oil shale or tar sands within the Green River, Piceance Creek, Uintah, and Washakie geologic basins, and shall give priority to implementing land exchanges in those basins."; and, "a land exchange…shall be implemented in accordance with Section 206 of FLPMA."

In September 2008, pursuant to Section 369 the Energy Policy Act of 2005, FLPMA, and NEPA, the BLM issued a Proposed Plan Amendments/Final Oil Shale and Tar Sands (OSTS) PEIS analyzing the environmental and socioeconomic impacts of amending 12 land use plans in Colorado, Utah, and Wyoming to designate public lands administered by the BLM as available

for commercial leasing for oil shale or tar sands development (BLM 2008a).[1] The November 17, 2008, ROD that followed this PEIS adopted the proposed land use amendments reflecting the allocation decisions analyzed in the 2008 OSTS PEIS (BLM 2008b). These land allocation decisions, which are currently in effect, were challenged in a lawsuit brought by a coalition of environmental organizations in January 2009. As part of a settlement agreement entered into by the United States to resolve the lawsuit and in light of new information that has emerged since the 2008 OSTS PEIS was prepared, the BLM has decided to take a fresh look at the land allocations analyzed in the 2008 OSTS PEIS and to consider excluding certain lands from future leasing of oil shale and tar sands resources. Specifically, the BLM, through its planning process, intends to take a hard look at whether it is appropriate for approximately 2,000,000 acres to remain available for potential development of oil shale and approximately 431,000 acres of public land to remain available for potential development of tar sands.

1.1 PURPOSE AND NEED

The BLM proposes to amend 10 land use plans in Colorado, Utah, and Wyoming to describe those areas that will be open and those that will be closed to application for commercial leasing, exploration, and development of oil shale[2] and tar sands resources. The analyses in this PEIS have been developed to evaluate the effects of this proposed action and its alternatives. The current land use plans in the study area describe land allocations analyzed in the 2008 OSTS PEIS and approved in the subsequent ROD (BLM 2008a,b).

As noted above, the BLM has decided to reconsider the 2008 allocations. The purpose and need for this proposed planning action is to reassess the appropriate mix of allowable uses with respect to oil shale and tar sands leasing and potential development. Specifically, the BLM will consider amending the applicable RMPs to specify whether any areas in Colorado, Utah, and Wyoming currently open for application for future leasing and development of oil shale or tar sands should not be available for such application for leasing and development. The phrase "available for application for leasing" is used above, and throughout the PEIS, rather than simply "available for leasing" to highlight that, unlike the BLM's practice with respect to oil and gas leasing, additional analysis, including but not limited to the NEPA, NHPA, and ESA, would be required prior to the issuance of any lease of oil shale or tar sands resources (see the Oil Shale and Tar Sands Development text box for more information).

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[1] While the 2008 Record of Decision (ROD) amended 12 land use plans, some of these plans were subsequently incorporated into revised plans. Therefore, the study area is now covered by 10 land use plans, which are being considered for amendment in this planning process.

[2] See the description of oil shale in Section 2.3 of this document. This PEIS does not address opening or closing lands to development of other resources or the hydraulic fracturing of other types of shale for the production of oil and gas.

1.1.1 Specific Scope and Objectives of the PEIS

The BLM published an April 14, 2011, Notice of Intent (NOI) to engage in land use planning and prepare an EIS that presents several reasons the agency decided to take a fresh look at land use allocations made in the 2008 ROD. Chief among these was new information not available in 2008, including a recently completed U.S. Geological Survey (USGS) in-place assessment of oil shale and nahcolite resources in Colorado, Utah, and Wyoming (USGS 2010a,b; 2011) and a March 2010 U.S. Fish and Wildlife Service (USFWS) Notice of Petition Findings, Endangered Wildlife and Plants, 12-Month Findings to List the Greater Sage-Grouse as Threatened or Endangered (75 FR 13910), concluding that while listing was warranted, it was precluded by higher priority listing actions. The BLM is currently engaged in planning initiatives in Wyoming, where much sage-grouse habitat is found, to consider adopting the Governor's sage-grouse Executive Order (E.O.), which identifies core areas to be protected and imposes additional restrictions on surface uses. In addition, the BLM has recently completed updating its inventory of lands having wilderness characteristics (LWC) in each of the three states for the planning area, and the status of several areas originally proposed to be Areas of Critical Environmental Concern (ACECs) in Utah has changed since the preparation of the 2008 OSTS PEIS. In light of the combined weight of these several developments, as well as other policy considerations, the BLM has decided to take another look at the land use plan allocations made in the 2008 ROD.

As was the case with the 2008 OSTS PEIS, the scope of the decisionmaking to be supported by the development of this PEIS is limited to an allocation decision. The analysis of potential impacts associated with oil shale and tar sands development in Chapters 4, 5, and 6 is programmatic in character and designed to disclose the potential impacts from future leasing and development, in order to provide the decision maker the available, essential information for making the allocation decision.

Consideration was also given to the possibility that the BLM might be able to issue additional research, development, and demonstration (RD&D) leases in the future. Section 369(c) of the Energy Policy Act of 2005 authorized the Secretary to make lands available to conduct research and development (R&D) activities. Because impacts from new RD&D projects are expected to be qualitatively similar to those of commercial oil shale projects, but smaller in scale until an RD&D lease is converted to a commercial lease and expanded to preference right acreage, land that will be open for commercial oil shale leasing will also be open for RD&D leasing. Therefore, although the term "commercial oil shale leasing" is used throughout this PEIS; this term is meant to encompass the issuance of RD&D leases as well.

The BLM also concluded that, as in the 2008 OSTS PEIS and ROD, the NEPA and other applicable analyses supporting this planning initiative do not provide the NEPA and other analyses for new RD&D leasing or conversion of RD&D leases to commercial leases. Rather, subsequent NEPA and other analyses at the leasing stage (whether oil shale, tar sands, or RD&D) will be required to determine the extent of the effect of oil shale and tar sands development when more specific information is known about the specific technologies being proposed and associated environmental consequences in the locations being proposed.

The BLM anticipates that oil shale development would proceed in a three-step decisionmaking process similar to that used for federal onshore oil and gas: (1) land use planning (i.e., amending RMPs), (2) leasing, and (3) project development. In the present experimental stage of the oil shale and tar sands industries, however, the BLM believes that the stages of NEPA compliance will be different from those used in oil and gas (see text box describing these steps).

As a result of the maturity of the oil and gas industry, the BLM is often able to include sufficient site-specific analysis in its NEPA documentation for amendments to RMPs so that an additional NEPA document is not required for issuing an oil and gas lease in conformance with the RMP. Nonetheless, the BLM also prepares a NEPA analysis before approving a plan of development or a drilling permit that would authorize significant disturbance of the leased area. The NEPA analysis for both decision levels includes cumulative effects analysis. Analysis of each oil and gas decision is based on technical information associated with the particular proposed action, as well as information about other reasonably foreseeable future actions in and near the area of the proposal.

In contrast, the present experimental state of the oil shale and tar sands industries does not allow this PEIS for land use plan amendments to include sufficient site-specific information or cumulative impact analysis to support issuance of a lease. Accordingly, prior to any actual oil shale leasing, additional NEPA and other applicable analyses will be required. Those analyses could result in decisions not to lease in specific areas or to lease in particular areas with stipulations, such as a stipulation precluding disturbance of the surface.

Under all programmatic oil shale and tar sands alternatives analyzed in this PEIS, land use plans would continue to (under the No Action Alternative) or be amended to (1) identify the most geologically prospective oil shale or tar sands resources within each planning unit, (2) designate lands within the most geologically prospective areas as available or not available for leasing, and (3) identify any technology restrictions. In addition, the following decisions from the 2008 ROD will be carried forward through this planning process: the requirement for future consultation activities, as well as compliance with all pertinent laws, regulations, and policies, including NEPA, NHPA, and ESA analyses; and the specific decision that the BLM will consider and give priority to the use of land exchanges to facilitate commercial oil shale development pursuant to Section 369(n) of the Energy Policy Act of 2005.

In summary, the PEIS is analyzing an allocation decision, the amendment of 10 existing land use plans to designate certain public lands as open, and certain other lands as closed for application for future oil shale and tar sands leasing.

If and when applications to lease are received and accepted, the BLM will conduct additional required analyses, including consideration of direct, indirect, and cumulative effects, reasonable alternatives, and possible mitigation measures, as well as assessment of the level of development that may be anticipated. On the basis of that analysis of future lease application(s), the BLM will establish general lease stipulations and best management practices (BMPs) and amend those plans, if necessary. After a lease is authorized, actual development will

require additional analysis to address the site-specific conditions of the proposed development and to develop mitigating measures.

1.2 SCOPE OF THE ANALYSIS

The NOI to prepare the *Programmatic Environmental Impact Statement and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the Bureau of Land Management in Colorado, Utah, and Wyoming* was published in the *Federal Register* (72 FR 21003–21005) on April 14, 2011. The NOI contained information regarding the need for the project, opportunities for public involvement, supplementary information regarding the project, planning criteria that would underlie the PEIS, and invited the public to comment on the proposed PEIS. Planning criteria are the standards, rules, and other factors used in formulating judgments about data collection, analysis, and decisionmaking associated with preparation of the PEIS. These criteria establish parameters and help focus preparation of the PEIS. The following are the planning criteria that were included in the NOI for the project and that will be considered during the preparation of the PEIS:

A. The PEIS and plan amendments will be completed in compliance with FLPMA and all applicable laws.

B. The BLM will work collaboratively with the states of Colorado, Utah, and Wyoming; tribal governments; county and municipal governments; other federal agencies; and all other interested groups, agencies, and individuals. Public participation will be encouraged throughout the process.

C. The proposed plan amendments analyzed in the PEIS would amend the appropriate individual land use plans specifically to address allocation of BLM-administered lands as open or closed to leasing and development of oil shale and tar sands resources.

D. Preparation of the PEIS and plan amendments will involve coordination with Indian tribal governments and will provide strategies for the protection of recognized traditional uses.

E. The BLM will coordinate with local, state, and federal agencies in the planning process and development of the PEIS to strive for consistency with their existing plans and policies, to the extent practicable.

F. Any decisions made on the basis of the planning process and development of the PEIS will take into account valid existing rights.

As stated in the NOI, this PEIS evaluates the potential impacts of designating lands as available or not available for commercial leasing of oil shale and tar sands resources that are located on public lands in Colorado, Utah, and Wyoming (Figures 1.2-1 and 1.2-2).

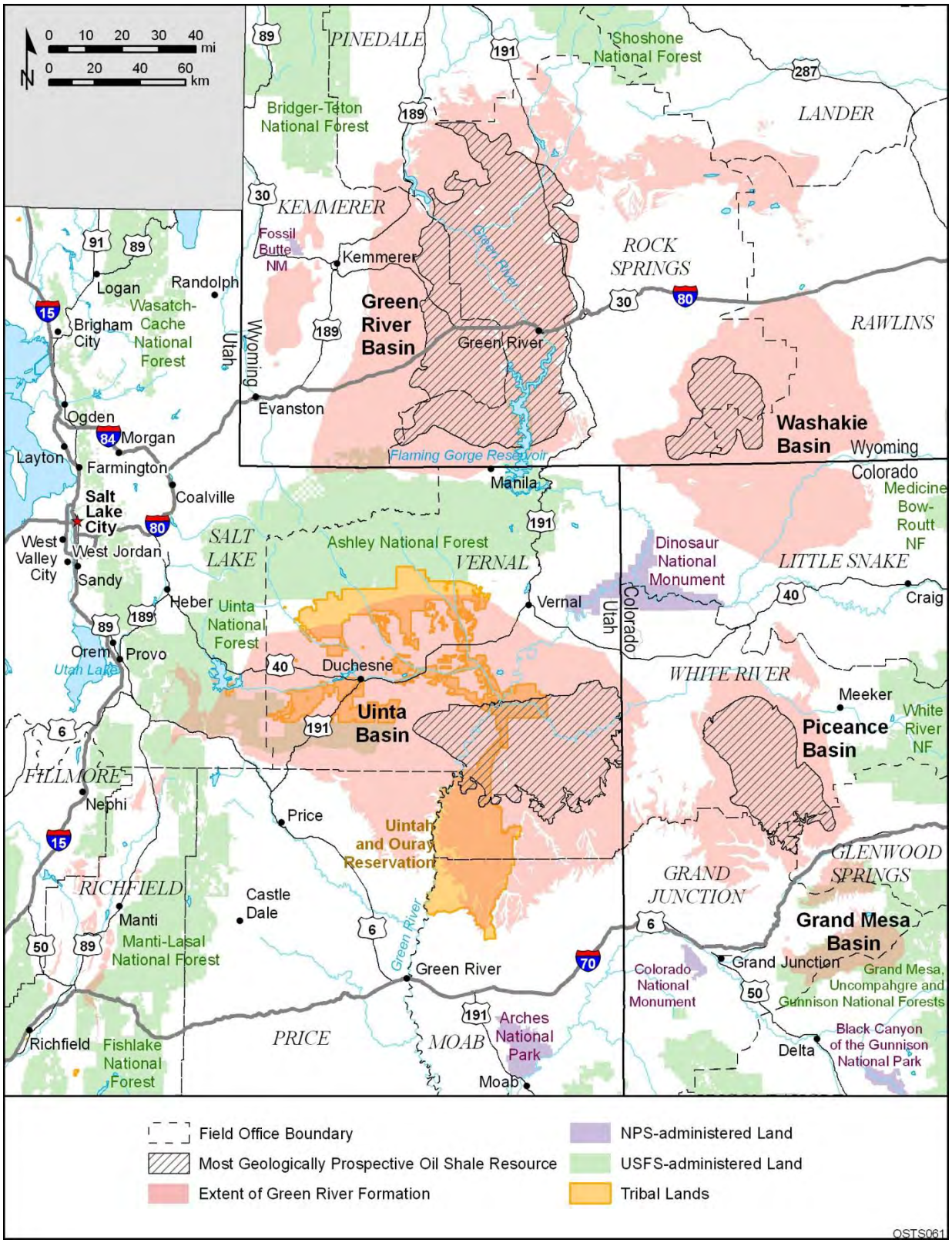

FIGURE 1.2-1 Most Geologically Prospective Oil Shale Resources within the Green River Formation Basins in Colorado, Utah, and Wyoming

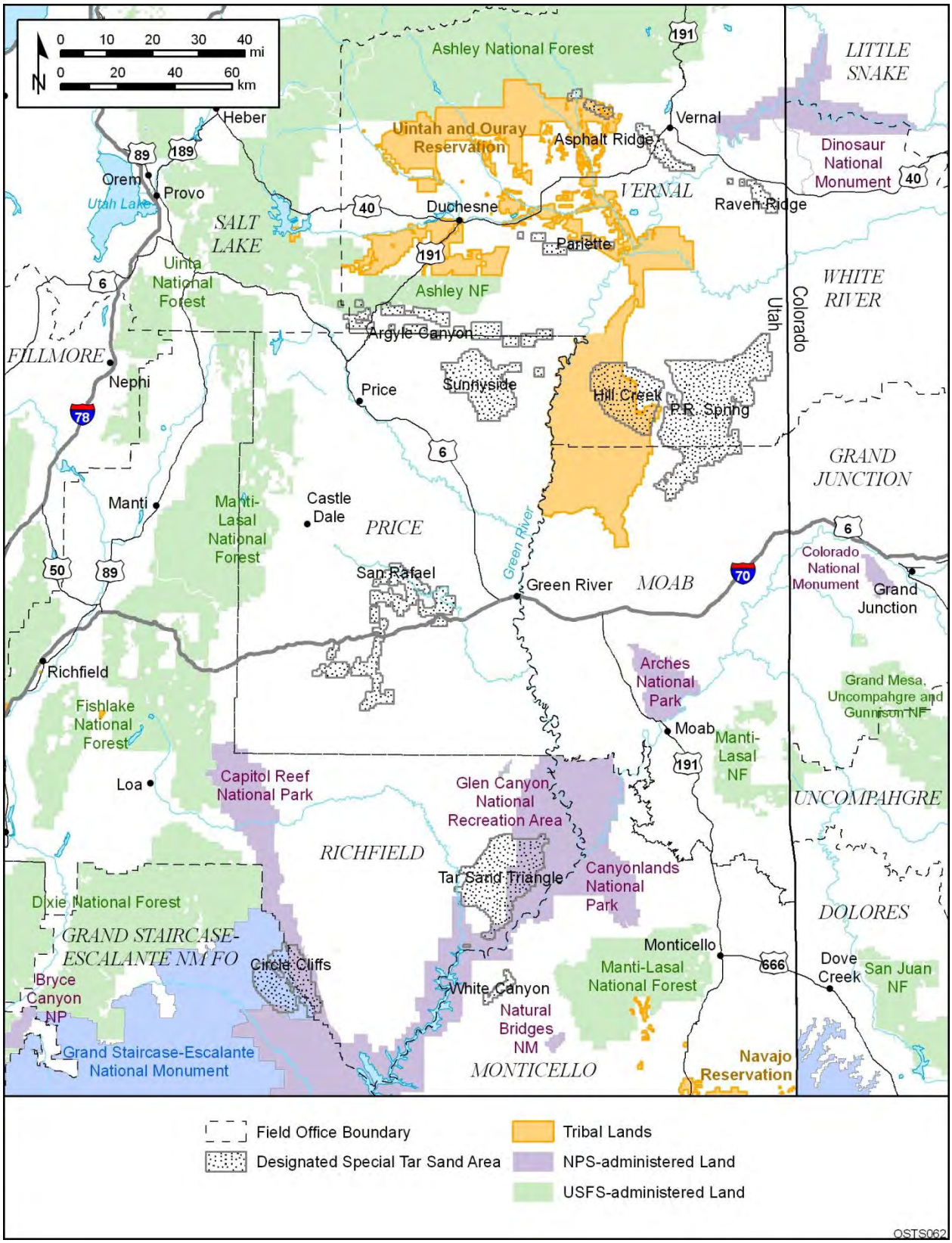

FIGURE 1.2-2 Special Tar Sand Areas in Utah

Specifically, the study area for the oil shale resources includes the most geologically prospective resources of the Green River Formation located in the Piceance, Uinta, Green River, and Washakie Basins.[3] For this planning initiative the BLM continues to employ the standard it developed pursuant to the Energy Policy Act of 2005, which is to focus on the most geologically prospective resources, as defined by grade and thickness of the deposits. For the purposes of this PEIS, the most geologically prospective oil shale resources in Colorado and Utah are those deposits that yield 25 gal of shale oil or more per ton of rock (gal/ton) and are 25 ft thick or greater. In Wyoming, where the oil shale resource quality is not as high as it is in Colorado and Utah, the most geologically prospective oil shale resources are those deposits that yield 15 gal/ton or more of shale oil and are 15 ft thick or greater. The BLM has identified the most geologically prospective areas for oil shale development on the basis of the grade and thickness of the deposits. For the purposes of this PEIS, the most geologically prospective oil shale resources in Colorado and Utah are those deposits that yield 25 gal/ton or more of oil shale and are 25 ft thick or greater. In Wyoming, where the oil shale resource is not of as high a quality as it is in Colorado and Utah, the most geologically prospective oil shale resources are those deposits that yield 15 gal/ton or more of oil shale and are 15 ft thick or greater. Figure 1.2-1 shows the oil shale basins, which were mapped on the basis of the extent of the Green River Formation, and the most geologically prospective oil shale resources within those basins.[4]

For tar sands resources, the study area includes those locations designated as Special Tar Sand Areas (STSAs) in the geologic reports (minutes) prepared by the USGS in 1980 (USGS 1980a–k) and formalized by Congress in the Combined Hydrocarbon Leasing Act of 1981 (P.L. 97-78).[5] Eleven STSAs were identified across different sedimentary provinces in Utah (Figure 1.2-2): Argyle Canyon–Willow Creek (hereafter referred to as Argyle Canyon), Asphalt Ridge–Whiterocks and Vicinity (hereafter referred to as Asphalt Ridge), Circle Cliffs East and West Flanks (hereafter referred to as Circle Cliffs), Hill Creek, Pariette, P.R. Spring, Raven Ridge–Rim Rock and Vicinity (hereafter referred to as Raven Ridge), San Rafael Swell,

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[3] The Piceance Basin is not referred to or described consistently in 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 southern province, which are roughly separated by the Colorado River and Interstate 70 (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. Various authors have used the terms "Piceance Basin" and "Piceance Creek Basin" to refer to either the overall basin or the northern area. In this PEIS, the focus is on the northern province, where the richest and thickest reserves are located, and the study area is referred to as the "Piceance Basin."

[4] Numerous sources of information were used to define the boundaries of the Green River Formation basins and the most geologically prospective oil shale resources. The basin boundaries were defined by digital data provided by the USGS taken from Green (1992), Green and Drouillard (1994), and Hintze et al. (2000). The most geologically prospective oil shale resources in the Piceance Basin were defined on the basis of digital data provided by the USGS taken from Pitman and Johnson (1978), Pitman (1979), and Pitman et al. (1989). In Wyoming, the most geologically prospective oil shale resources were defined on the basis of detailed analyses of available oil shale assay data (Wiig 2006a,b). In Utah, the most geologically prospective oil shale resources were defined by digital data provided by the BLM Utah State Office.

[5] The boundaries of the designated STSAs were determined by the Secretary of the Interior's orders of November 20, 1980 (45 FR 76800–76801), and January 21, 1981 (46 FR 6077–6078).

Sunnyside and Vicinity (hereafter referred to as Sunnyside), Tar Sand Triangle, and White Canyon.

The oil shale and tar sands resources that fall within the defined study areas are located within the jurisdiction of 10 separate BLM field offices or administrative units. These include the Colorado River Valley (formerly the Glenwood Springs), Grand Junction, and White River Field Offices in Colorado; the Monticello, Price, Richfield, and Vernal Field Offices in Utah; and the Kemmerer, Rawlins, and Rock Springs Field Offices in Wyoming.[6] The subsequent ROD will modify the decisions in the land use plans, as appropriate.

The scope of this PEIS includes public lands managed by the BLM where the federal government owns both the surface estate and subsurface mineral rights. In addition, BLM-managed lands where the federal government owns the subsurface mineral rights but the surface estate is owned by tribes, states, or private parties (i.e., split estate lands) are included in the scope of this analysis. Tribal lands where both the surface estate and subsurface mineral estate are owned by the tribe are not included in the scope of analysis of this PEIS.

The BLM has determined that certain lands within the oil shale and tar sands resource areas are excluded from commercial leasing on the basis of existing laws and regulations, E.O.s, administrative land use plan designations as noted below, or withdrawals. As a result, commercial leasing is excluded from Naval Oil Shale Reserves (NOSR) Numbers 1 and 3,[7] all designated Wilderness Areas, Wilderness Study Areas (WSAs), other areas that are part of the National Landscape Conservation System (NLCS) managed by the BLM (e.g., National Monuments, National Conservation Areas [NCAs], Wild and Scenic Rivers [WSRs], and National Historic and Scenic Trails), and existing ACECs that are currently closed to mineral development. As discussed in Chapter 2, additional areas are closed and will not be available for the future opportunity to lease for oil shale and tar sands on the basis of local planning decisions.

Ten land use plans will be amended to designate lands as available or not available for commercial oil shale leasing, and four land use plans will be amended to designate lands as available or not available for commercial tar sands leasing. Three of the plans that are to be amended contain both oil shale and tar sands resources.

The oil shale and tar sands plan alternatives are described in Chapter 2 of the PEIS, including summary tables comparing the potential impact of the alternatives. For information purposes, the tables also include information on potential impacts that could accompany future commercial development of oil shale and tar sands resources. Chapter 3 describes the affected environment of the study area. The potential impacts of commercial oil shale and tar sands development are described in Chapters 4 and 5, respectively. Chapter 6 assesses the impacts of

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[6] Although the P.R. Spring STSA extends into the Moab Field Office boundary, this area is administered by the Vernal Field Office under a Memorandum of Understanding (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.

[7] These Reserves were erroneously included in the maps and acreage totals identified as open for oil shale leasing in the 2008 PEIS and ROD. As explained in Section 2.3.3 of this PEIS, this error has been corrected.

the different alternatives evaluated in this PEIS, provides a comparison of the alternatives, and provides an assessment of cumulative impacts. Chapter 7 contains a summary of the consultation and coordination associated with the PEIS. Chapter 8 contains the list of preparers of the PEIS, and Chapter 9 is the Glossary. Appendices A and B provide overviews of the oil shale and tar sands technologies that might be used over the next 20 years. Appendix C details the proposed land use plan amendments associated with the proposed alternatives. Appendix D summarizes the potentially applicable federal, state, and county regulatory requirements for oil shale and tar sands development. Appendices E and F contain relevant biological data for the three-state study area and the proposed conservation measures for the preferred alternative. Appendix G details the methodology used for the socioeconomics assessment. Appendix H describes the approach used for interviewing selected residents of the oil shale and tar sands project area in the preparation of the 2008 PEIS, Appendix I provides the instream flow water rights in the Piceance Basin, Colorado, and Appendix J is the Summary of Public Scoping Comments for this PEIS.

The scope of the analysis for this PEIS does not include review of the decisions by the Secretary to issue the RD&D leases described in Section 1.4.1. Those leases authorize activities on six 160-acre parcels located in Colorado and Utah (see Figure 2.3-2 of this PEIS) and also identify conditions under which commercial development could occur on 4,970 acres of preference right lease areas (PRLAs) included in the leases. A total of 30,720 acres may be developed under the terms of these leases. A call for nominations for a second round of RD&D leases was published in the *Federal Register* on November 3, 2009. Three nominations were received (two in Colorado, one in Utah); these proposed parcels are currently undergoing NEPA analysis. Under that solicitation, certain provisions in the terms of the new RD&D leases will change. The new leases, if granted, will contain terms that authorize RD&D activity on 160-acre parcels and will also identify conditions under which commercial development could occur on an additional 480 acres of PRLAs included in each of the leases. If all three leases are issued, a total of 1,920 acres may be developed under the terms of these leases. The RD&D leases are prior existing rights and are not the subject of decisions within this PEIS, with the exception that all alternatives address the subsequent availability of the lands contained in the leases should the initial leaseholder relinquish the existing leases.

In accordance with Section 369(n) of the Energy Policy Act of 2005, and as carried forward from the 2008 ROD, the BLM will consider and give priority to the use of land exchanges, where appropriate and feasible, to consolidate land ownership and mineral interests within the oil shale basins and STSAs. If the current BLM land use plan does not allow for exchanges, it may be amended to include specific language allowing land exchanges to facilitate commercial oil shale or tar sands development. However, because the possible locations for such future exchanges are unknown at this time, the scope of this PEIS does not include evaluations of potential impacts of such exchanges, and leasing for commercial development on these lands would be subject to additional NEPA review.

1.2.1 Issues Raised during Public Scoping

Public scoping meetings were held at seven locations in April and May of 2011: Salt Lake City, Utah (April 26); Price, Utah (April 27); Vernal, Utah (April 28); Rock Springs,

Wyoming (April 29); Rifle, Colorado (May 3); Denver, Colorado (May 4); and Cheyenne, Wyoming (May 5). Meetings were held at 1:00 p.m. and 7:00 p.m. at each location, and a court reporter recorded a transcript for each meeting. At each meeting, the BLM presented background information about the OSTS PEIS and related activities.

More than 392 people registered their attendance at the public meetings. Approximately 4,663 individuals, organizations, and governmental agencies provided comments or suggestions on the scope of the PEIS.

Issues discussed in comments received during the public scoping period for the OSTS PEIS were placed into three major categories in the preparation of the PEIS: (1) issues within the scope of the PEIS; (2) issues outside the scope of the PEIS, but which may present related policy considerations; and (3) issues considered to be outside the scope of the PEIS as defined in the April 14, 2011, NOI. A detailed presentation and categorization of issues raised in public scoping comments is presented in Appendix J.

General issues within the scope of the PEIS included questions and concerns regarding the environmental and socioeconomic impacts of oil shale and tar sands development, resource assessments, sources and impacts of power production required for development, technologies to be used, stakeholder participation in the NEPA process, cumulative impacts, mitigation and reclamation, leasing, multiple use conflicts, consistency of the PEIS with state and local plans, land use planning, and development of alternatives to be analyzed, including the identification of exclusion areas.

Specific environmental issues within the scope of the PEIS related to the potentially significant disturbance to the surface and subsurface environment resulting from the development of oil shale and tar sands resources, including effects on water quantity and quality, air quality, topography, natural and sensitive landscapes, wildlife habitat and populations, sensitive and endangered species, sage-grouse habitat, aquatic habitats and species, vegetation and habitat dynamics, cultural and historical resources, LWC, human health, and climate.

Issues determined to be outside the scope of the PEIS, but which may present related policy considerations, included those related to the need for a new PEIS; deferment of decisions until RD&D project results are available; oil shale regulations and national policy; deferment of analysis of environmental consequences to project-level NEPA evaluations; bonding requirements for leasing companies for future reclamation; determining commercial royalty rates; and establishment of federal subsidies, incentives, and taxes.

Issues determined to fall outside the scope of the PEIS because they were not pertinent to the purpose and need for the proposed land use planning decision as described in the NOI included issues relating to evaluations and support of other energy sources (e.g., renewable energy resources, clean technologies, biofuels, geothermal, nuclear power, and conventional oil and gas resources); energy conservation measures; price of fossil fuels; sale of resulting shale oil on the international market; support for development on private lands; development and use of all fossil fuels and effects on climate change; foreign oil as a national security issue;

denial/approval of mining permits; and oil shale and tar sands development impact on oil and gas prices.

1.2.2 Environmental Impact Analysis in This PEIS

The analysis of environmental effects in this PEIS is made up of two main components. The first is an analysis of generic, hypothetical, commercial facilities for each of the major types of oil shale and tar sands technologies resulting in the development of impacting factors for affected environmental resources. In cases in which information on impacting factors was not available for commercial oil shale or tar sands technologies, such factors were developed from analogous experience in the oil and gas industry. These factors and the resulting environmental effects of generic commercial-scale facilities are described in Chapter 4 for oil shale technologies and in Chapter 5 for tar sands technologies. The second main component of the environmental impacts analysis draws on the expected environmental effects of oil shale RD&D projects on the six 160-acre RD&D leases mentioned above as analyzed in the Environmental Assessments (EAs) prepared for those projects. RD&D project summaries are provided in Appendix A.

A reasonably foreseeable development scenario (RFDS) is an analytical tool, often used in the planning process, that can inform analyses prepared pursuant to NEPA. An RFDS is a reasonable projection of the most likely anticipated oil shale and tar sands activity supported by a clear level of assumptions. An RFDS was not developed for this planning initiative, however, because information regarding possible development of these resources remains highly speculative. Analysis of the effects of development at the programmatic level will be qualitative to stay within the limited scope of the planning decisions to be made, as well as to reflect the limited and/or highly speculative nature of the information available.

If and when applications to lease oil shale and tar sands resources for commercial development are received and accepted by the BLM and when information is less speculative, it will be possible to develop an RFDS. That RFDS will be the critical component for performing a thorough effects analysis of oil shale and tar sands activities that could occur as a result of leasing. An RFDS for an area of proposed oil shale and tar sands leasing provides information for evaluating the type and extent of potential effects from oil shale and tar sands development that *could* occur. Effects analysis for leasing is broad and generalized because it is necessarily based on a *hypothetical* scenario of exploration and development.

At the project level, the plan of development provides the specific technical information necessary for the analysis of environmental consequences of these operations, including analysis of cumulative effects of the proposed action. An exploration or development permit is definitive for activities that will involve ground disturbance, unlike the speculative RFDS used to analyze effects related to a leasing decision. Consequently, the nature and extent of effects from the proposed exploration or development action can be determined with a higher degree of accuracy and confidence than that associated with a planning- or leasing-level RFDS.

1.3 COOPERATING AGENCIES

The scope of the *Programmatic Environmental Impact Statement and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the Bureau of Land Management in Colorado, Utah, and Wyoming* is of interest to numerous federal, tribal, state, and local governments. The BLM invited 55 agencies to participate in the preparation of the PEIS as cooperating agencies. Fifteen agencies expressed an interest in participating as cooperating agencies, and MOUs between these agencies and the BLM were established. The following agencies are participating as cooperating agencies in the preparation of this PEIS:

- National Park Service (NPS);
- USFWS;
- State of Colorado Department of Natural Resources (Colorado DNR) and Department of Public Health and the Environment (CDPHE);
- State of Utah;
- State of Wyoming;
- Garfield County, Colorado;
- City of Rifle, Colorado;
- Carbon County, Utah;
- Duchesne County, Utah;
- Grand County, Utah;
- Uintah County, Utah;
- Lincoln County, Wyoming;
- Sweetwater County, Wyoming; and
- Coalition of Local Governments.

The roles and responsibilities of these cooperating agencies, and the extent of interactions between them and the BLM, are discussed in Chapter 7.

1.4 RELATIONSHIP OF THE PROPOSED ACTION TO OTHER BLM AND COOPERATING AGENCY PROGRAMS, POLICIES, AND PLANS

1.4.1 BLM's Oil Shale Research, Development, and Demonstration Program

On June 9, 2005, pursuant to its authority under Section 21 of the Mineral Leasing Act (MLA) (30 USC 241), the BLM initiated an oil shale RD&D program under which small tracts of land could be leased in support of activities to demonstrate the technical and economic feasibility of oil shale extractive technologies (70 FR 33753–33759). The BLM solicited the nomination of parcels, not to exceed 160 acres, to be used for oil shale RD&D activities. Applicants also were allowed to identify an additional contiguous 4,960 acres of land to be reserved as a PRLA for future commercial development, to be awarded subject to the following terms:

(a) Upon documenting to the satisfaction of the authorized officer that it has produced commercial quantities of shale oil from the lease, the Lessee has the exclusive right to convert the research and development lease acreage to a commercial lease and acquire any or all portions of the remaining preference lease area up to a total of 5,120 contiguous acres upon:

(1) Payment of a bonus based on the Fair Market Value of the lease, to be determined by the Lessor utilizing criteria to be developed through the rulemaking described in subsection (b) or other process for obtaining public input;

(2) Documentation of the Lessee's consultation with state and local officials to develop a plan for mitigating the socioeconomic impacts of commercial development on communities and infrastructure;

(3) Provision of adequate bond to cover all costs associated with reclamation and abandonment of the expanded lease area; and

(4) BLM's determination, following analysis pursuant to NEPA, that commercial-scale operations can be conducted, subject to mitigation measures to be specified in stipulations or regulations, without unacceptable environmental consequences.

(b) Such commercial lease shall contain terms consistent with regulations to be developed by the Secretary pursuant to section 21 of the Act and stipulations developed through appropriate NEPA analysis.

(c) Such commercial lease may be issued for a term of 20 years and so long thereafter as shale oil is produced from the Leased Lands in commercial quantities. Such commercial lease shall be subject to payment of rents and royalties to the Lessor at the established rates at the time of lease conversion,

> or at such reduced rate that the Lessee demonstrates is necessary to permit the economic development of the oil shale resource. The royalty shall be subject to the readjustment of lease terms at the end of the 20th lease year and each 20-year period thereafter.

The 160-acre RD&D leases were issued for 10-year terms with an option to extend them up to another 5 years. Prior to beginning RD&D activities, the lessees also must obtain permits from the BLM and other governmental agencies (e.g., state-issued air quality permits). These RD&D leases and the conversion right to commercial operations on preference acreage represent a prior existing right that may be exercised upon compliance with the terms of the lease.

The BLM received and reviewed a total of 20 nomination packages. Ultimately, six projects were selected for further consideration, including preparation of EAs under NEPA. The projects that were selected included five projects in the Piceance Basin, Colorado (one each submitted by Chevron Shale Oil Company and EGL Resources, Inc. [EGL],[8] and three submitted by Shell Frontier Oil & Gas), and one project in the Uinta Basin, Utah (submitted by Oil Shale Exploration Company [OSEC]).[9] The RD&D leases for the five Colorado projects were issued January 1, 2007; the lease for the Utah project was issued in June 2007. The RD&D leases are part of the baseline activities under all alternatives considered in the PEIS. More information about these RD&D projects is provided in Section 2.3 and Appendix A.

A second round of solicitations of interest in RD&D leases was issued by the BLM on November 3, 2009 (74 FR 56867). Any new RD&D lease would have to be consistent with the applicable BLM land use plans. Three nomination packages were submitted; all three were selected for further consideration, including preparation of EAs under NEPA. The projects that were selected include two projects in the Piceance Basin, Colorado (one from Exxon-Mobil Exploration Company and one from Natural Soda Holdings, Inc.) and one project in the Uintah Basin, Utah, submitted by Aurasource. These projects are undergoing NEPA analysis. The impacts of new RD&D leasing are anticipated to be qualitatively similar to those of commercial oil shale leasing as analyzed in this PEIS.

The RD&D impacts, however, are anticipated to be smaller in scale than those of commercial projects, at least until any RD&D lease might be converted to a commercial oil shale lease and expanded to include preference right acreage. Therefore, the analysis in this PEIS for commercial oil shale projects also provides sufficient analysis of RD&D projects for purposes of amending land use plans. New RD&D leases would be issued, if at all, only after site-specific analysis under NEPA. Conversion to commercial leases would also require an individualized NEPA document.

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8 Since the preparation of this PEIS, EGL Resources, Inc., has become American Shale Oil, LLC.

9 Since the preparation of this PEIS, OSEC has become Enefit American Oil.

1.4.2 Combined Hydrocarbon Leasing Program and Leasing in STSAs Issued under the Revised MLA

The Combined Hydrocarbon Leasing Act of 1981 (P.L. 97-78) amended the MLA to authorize the Secretary to issue combined hydrocarbon leases (CHLs) in areas containing substantial deposits of tar sands, which were to be designated as STSAs. This Act further specified that a CHL was the only type of lease that could be offered in these STSAs, provided for the conversion of existing oil and gas leases or tar sands claims in these areas to CHLs, and established the maximum lease size as 5,120 acres. The Combined Hydrocarbon Leasing Act defined oil as all nongaseous hydrocarbons except coal, oil shale, gilsonite, and other vein-type solid hydrocarbons. Eleven STSAs were designated in 1980 and 1981. The BLM published regulations implementing the leasing provisions of this Act in February 1983 at 43 CFR Part 3140. Subsequently, the BLM prepared the *Utah Combined Hydrocarbon Leasing EIS* (BLM 1984). Tar sands resources located outside of these STSAs were not subject to the requirements of 43 CFR Part 3140 and are available for development under oil and gas leases.

Under the authority of the Combined Hydrocarbon Leasing Act, six CHLs were issued in the mid-1980s within the Pariette and P.R. Spring STSAs in the Vernal Field Office; these leases remain in existence. Also in the mid-1980s, a number of operators holding oil and gas leases or tar sands claims within the designated STSAs applied to convert their leases to CHLs. In most instances, the conversion of these leases has not been completed; thus a number of pending conversion applications remain within the study area, specifically within the Circle Cliffs, Tar Sand Triangle, and P.R. Spring STSAs. The BLM is currently engaged in adjudication of these applications.

On May 18, 2006, pursuant to Section 350 of the Energy Policy Act of 2005, which amended the MLA to allow separate oil and gas leases and tar sands leases in designated STSAs, the BLM issued a final rule on leasing in STSAs (71 FR 28779, codified at 43 CFR Subpart 3141). The final rule authorizes the BLM to issue separate leases for exploration for and extraction of tar sands, separate leases for exploration for and development of oil and gas, and separate leases for CHLs within designated STSAs. Under the rule, all three types of leases would have primary terms of 10 years; CHLs and oil and gas leases would remain in effect as long thereafter as oil or gas is produced in commercial quantities; tar sands leases would remain in effect after the 10-year term as long as tar sands are produced in commercial quantities. The final rule increases the maximum acreage of CHLs or tar sands leases in an STSA from 5,120 to 5,760 acres, establishes the minimum acceptable bid for tar sands leases at $2.00 per acre, and requires that tar sands leases be issued by competitive processes only. In addition, under the final rule, leasing STSAs in NPS units is allowed only where mineral leasing is permitted by law and where the lands are open to mineral resource disposition in accordance with any applicable Minerals Management Plan. The NPS Regional Director also must find that leasing within an NPS unit would not result in any significant adverse impacts on the NPS unit or any contiguous unit.

Decisions in the ROD resulting from this PEIS regarding the availability of lands within the STSAs for future commercial leasing will not affect or be affected by the requirements established for tar sands leasing in the final rule.

1.4.3 Existing BLM Land Use Plans, Ongoing Planning Activities, and Resource Management Plan Revisions

The BLM develops land use plans to guide activities, establish management goals and approaches, establish land use allocations within a planning area, and provide management prescriptions for public lands. Current generation land use plans are called Resource Management Plans (RMPs); in the past, such plans were called Management Framework Plans (MFPs), and some MFPs are still in use. Decisions in existing BLM land use plans were incorporated into the analyses conducted in preparation of this PEIS and are discussed in Section 3.1.1. Of the existing land use plans within the study area, the BLM is currently engaged in planning efforts to revise, amend, or prepare new versions of four of the plans. The existing plans within the PEIS study area include the following:

- Colorado
  - Glenwood Springs RMP (BLM 1988, as amended by the 2006 Roan Plateau Plan Amendment [BLM 2006a, 2007, 2008d])[10]
  - Grand Junction RMP (BLM 1987)
  - White River RMP (BLM 1997a, as amended by the 2006 Roan Plateau Plan Amendment [BLM 2006a, 2007, 2008d])[11]

- Utah
  - Monticello RMP (BLM 2008e)
  - Price RMP (BLM 2008f)
  - Richfield RMP (BLM 2008g)
  - Vernal RMP (BLM 2008h)
  - Grand Staircase–Escalante National Monument (GSENM) Management Plan (BLM 1999)

- Wyoming
  - Green River RMP (BLM 1997b, as amended by the Jack Morrow Hills Coordinated Activity Plan [BLM 2006b])
  - Kemmerer RMP (BLM 2010a)
  - Rawlins RMP (BLM 2008i)

With the exception of the RMP for the GSENM (BLM 1999), these existing BLM land use plans will be amended by decisions contained in the ROD for the PEIS. The proposed land use plan amendments are discussed in Chapter 2 and are presented in Appendix C.

When the amendments/revisions/replacements of four RMPs currently undergoing planning (Grand Junction, Colorado River Valley, Green River, and White River Field Office) were initiated, there was no reasonably foreseeable development projected for tar sands or oil

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[10] The Glenwood Springs Field Office moved to Silt, Colorado, and is now called the Colorado River Valley Field Office, although the current RMP is still titled the Glenwood Springs RMP. When the plan revision is approved, it will be called the Colorado River Valley RMP.

[11] These plans are currently undergoing revision, amendment, or replacement.

shale over the life of these plans, and for that reason, identification of areas available for potential oil shale or tar sands leasing was not considered as part of those planning processes. The mineral reports prepared to accompany the three RMPs did identify oil shale resources, but did not project any leasing or development because of prevailing and anticipated economic factors. The fourth RMP effort, the amendment of the White River RMP, is being conducted specifically to consider the amendment of that RMP to allow additional oil and gas development activity. It was recognized at the time that this PEIS would consider the issue of oil shale management for the White River RMP area.

On December 13, 2005, the BLM published a NOI in the *Federal Register* initiating a PEIS to support a commercial oil shale and tar sands leasing program on federal lands in these three states. Early in the development of the draft, the scope of that PEIS was revised to focus only on decisionmaking regarding allocation of lands as open or closed, because the BLM determined that the analysis of environmental consequences of commercial oil shale and tar sands development would not be sufficiently detailed to support lease issuance. The BLM made this determination on the basis that the development technologies for in situ production of oil shale were just emerging and that, therefore, there was a lack of information regarding resource use and associated impacts.

During the ensuing 3 years since the 2008 OSTS PEIS and ROD, the BLM has not received any new information from the existing RD&D lessees that could provide sufficiently detailed analysis of the environmental consequences of commercial oil shale development to support lease issuance. The situation is similar with respect to the lack of information regarding the technological and environmental requirements of commercial tar sands development. Consequently, as with the 2008 OSTS PEIS and ROD, this PEIS is similar in scope, supporting only resource allocation decisionmaking that identifies the BLM-managed lands for which applications to lease oil shale and tar sands resources would or would not be accepted in the future. That is, although applications would be accepted for areas that may be identified as available for commercial leasing, the BLM will need to comply with all applicable laws, regulations, and policies, including but not limited to the requirements of NEPA, NHPA, and ESA before any leasing of the area would be considered (see text box describing the steps in the development decisionmaking process).

The ROD for the Final OSTS PEIS will amend the land use plans existing at the time of its adoption, identifying those areas designated as open or closed for application for future oil shale and tar sands leasing.

1.4.4 Leasing

As part of the site-specific analysis to be carried out prior to issuance of any oil shale or tar sands leases, the environmental consequences to specific resource values and uses within the areas and any alternative actions would be analyzed. At that time, at the site-specific level, the competing resource values will be analyzed and weighed as required by FLPMA and NEPA, and a decision will be made regarding management of the specific parcel of land. If, pursuant to the lease evaluation and land use planning process, the BLM determines that leasing and subsequent

development of the oil shale or tar sands resources would cause significant impacts, the BLM can require the applicant to mitigate the impact so that it is no longer significant or move the proposed lease location. If neither of these options resolves the anticipated conflicts, the BLM can decide either that the importance of development of the oil shale and tar sands resources outweighs protection of the competing resource value and approve the application, or that the resource value outweighs the advantages of development and deny the application.

This preleasing NEPA and other coordinated analyses would include the same opportunities for public involvement and comment that are part of this PEIS process and every other planning and NEPA process the BLM undertakes. The decisions associated with the PEIS will be incorporated into the ongoing RMPs as they are finalized or will amend the existing RMPs, depending on the order in which the documents are completed with respect to the completion of the PEIS.

Although the BLM handbooks provide for stipulations for oil and gas leases to be made part of the land use plans, that guidance is not applicable to the present analysis to amend land use plans for development of oil shale or tar sands. Oil and gas is a mature industry in which there is long experience with leasing stipulations to conserve and to protect affected resources. The present experimental stage of the oil shale and tar sands industries weighs against emplacing lease stipulations in the RMPs at this time. Instead, the BLM will develop appropriate lease stipulations and either (1) include them in appropriate RMPs as part of future amendments or (2) include them in commercial lease sale announcements. That will allow the BLM to refine lease stipulations over time based on the latest information regarding oil shale or tar sands technologies and their impacts, without unnecessary rounds of amendments to the land use plans. This PEIS does discuss various mitigation requirements, methods, and objectives that will inform both (1) the lease stipulations developed for particular lease sales or for future amendments to RMPs and (2) the conditions of approval for plans of development.

1.4.5 Cooperating Agency Plans and Programs

As discussed in Section 1.3, this PEIS has been prepared in cooperation with 14 federal, state, and local governmental organizations. Management plans and programs established by these cooperating agencies have been considered in the preparation of this PEIS on the basis of information provided by the agencies. An allocation decision identifying lands as available for application to lease permits the BLM to consider only applications to lease and does not grant any property right. It does not authorize any ground-disturbing activities, nor is it an irreversible or irretrievable commitment of resources under NEPA. The BLM will cooperate with state, local, and tribal governments to promote consistency with their land use plans, where possible. For example, the City of Rifle has indicated to the BLM, on a preliminary basis, that it believes the BLM's allocation decisions to be in conflict with its plan regarding economic development.

1.4.6 Other BLM Programmatic Energy-Related Land Use Planning Initiatives

1.4.6.1 BLM and U.S. Forest Service (USFS) Energy Corridor Designation (2008)

In accordance with Section 368 of the Energy Policy Act of 2005, the BLM and USFS, working with the U.S. Department of Energy (DOE) and U.S. Department of Defense (DoD), prepared a PEIS evaluating issues associated with the designation of energy corridors on federal lands in 11 Western states, including Colorado, Utah, and Wyoming. On the basis of this Final West-wide Energy Corridors PEIS (DOE and DOI 2008), the BLM and USFS amended their respective land use plans to designate a series of energy corridors across the western states. These potential amendments do overlap the planning areas included within the OSTS PEIS area. In addition, the designation of energy corridors may impact energy development throughout the western United States, including commercial oil shale and tar sands development, because the location of energy corridors may facilitate development by removing administrative and planning barriers for potential pipelines, electric transmission lines, and associated infrastructure. The Final West-wide Energy Corridors PEIS is available at http://corridoreis.anl.gov.

1.4.6.2 BLM and USFS Programmatic EIS for Geothermal Leasing (2008)

In accordance with the Energy Policy Act of 2005 (P.L. 109-58), the BLM and USFS proposed a program to facilitate geothermal leasing on lands administered by the BLM and the USFS (National Forest System [NFS] lands) that have geothermal potential in 12 western states, including Alaska, some of which overlap the OSTS PEIS study area . Under the proposal, the BLM and USFS would do the following: (1) identify public and NFS lands with geothermal potential as being legally open or closed to leasing; (2) issue or deny geothermal lease applications pending as of January 1, 2005; (3) identify public lands that are administratively closed or open, and under what conditions; (4) develop a comprehensive list of stipulations, BMPs, and procedures to serve as consistent guidance for future geothermal leasing and development on public and NFS lands; and (5) amend BLM land use plans to adopt the resource allocations, stipulations, BMPs, and procedures. The program is described and analyzed in the Final PEIS for Geothermal Leasing in the Western United States published in October 2008 (BLM 2008j). A ROD for the program was issued in December 2008 (BLM 2008k).

1.4.6.3 BLM and DOE Programmatic EIS for Solar Energy Development (initiated 2009)

On March 11, 2009, the Secretary of the Interior issued Secretarial Order 3285, which announced a policy goal of identifying and prioritizing specific locations best suited for large-scale (i.e., utility-scale) production of solar energy on public lands (Secretary of the Interior 2010). The Secretarial Order directs the DOI to work with individual states, tribes, local governments, and other interested stakeholders to identify appropriate areas for generation and necessary transmission of solar energy, to develop BMPs for renewable energy and transmission projects on public lands to ensure the most environmentally responsible development and

delivery, and to establish clear policy direction for authorizing the development of solar energy on public lands. The proposed Solar Energy Development Program has been designed to meet these requirements and to serve as an analytical tool to assist the BLM in considering replacement of its current solar energy development policy with a comprehensive Solar Energy Development Program that would allow the permitting of future solar energy projects to proceed in a more standardized and efficient manner. The program is described and analyzed in the Draft Solar PEIS published in December 2010 (BLM and DOE 2010) and in the Supplement to the Draft Solar PEIS published in October 2011. Some of the public lands within the Solar Energy Development Program planning area overlap with the OSTS PEIS study area.

1.5 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.

BLM (Bureau of Land Management), 1984, *Utah Combined Hydrocarbon Leasing Regional Final EIS*, *Volume I: Regional Analyses*, Utah State Office, Salt Lake City, Utah, June.

BLM, 1987, *Grand Junction Resource Area Resource Management Plan and Record of Decision*, Grand Junction District, Colo., Jan.

BLM, 1988, *Record of Decision and Resource Management Plan*, Glenwood Springs Resource Area, Grand Junction District, Colo., June.

BLM, 1997a, *White River Record of Decision and Approved Resource Management Plan*, White River Resource Area, Craig District, Meeker, Colo., July.

BLM, 1997b, *Record of Decision and Green River Resource Management Plan*, Green River Resource Area, Rock Springs District Office, Wyo., Oct.

BLM, 1999, *Grand Staircase–Escalante National Monument Approved Management Plan Record of Decision,* Grand Staircase–Escalante National Monument, Cedar City, Utah, Nov.

BLM, 2006a, *Roan Plateau Planning Area, Including Former Naval Oil Shale Reserves Numbers 1 & 3, Resource Management Plan Amendment & Environmental Impact Statement*, *Final*, Colorado State Office, Aug. Available at http://www.blm.gov/rmp/co/roanplateau/final_eis_document.htm.

BLM, 2006b, *Record of Decision and Jack Morrow Hills Coordinated Activity Plan/Proposed Green River Resource Management Plan Amendment*, Rock Springs Field Office, Wyo., July.

BLM, 2007, *Record of Decision for the Approval of Portions of the Roan Plateau Management Plan Amendment and Environmental Impact Statement*, Glenwood Springs Field Office, Colo., June.

BLM, 2008a, *Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocation in Colorado, Utah, and Wyoming and Final Programmatic Environmental Impact Statement,* FES 08-32, Sept. Available at http://ostseis.anl.gov/.

BLM, 2008b, *Record of Decision for the Oil Shale and Tar Sands Resources Resource Management Plan Amendments,* Nov. 17.

BLM, 2008c, *National Environmental Policy Act Handbook*, BLM Handbook H-1790-1, Washington, D.C., Jan.

BLM, 2008d, *Record of Decision for the Resource Management Plan Amendment for Portions of the Roan Plateau Planning Area Designated as Areas of Critical Environmental Concern Public Lands in Garfield County, CO*, March.

BLM, 2008e, *Proposed Resource Management Plan and Final Environmental Impact Statement*, Monticello Field Office, Utah, Aug.

BLM, 2008f, *Proposed Resource Management Plan and Final Environmental Impact Statement for the Price Field Office*, Price Field Office, Utah, Aug.

BLM, 2008g, *Richfield Field Office Proposed Resource Management Plan & Final Environmental Impact Statement*, Richfield Field Office, Utah, Aug.

BLM, 2008h, *Proposed Resource Management Plan Revision and Final Environmental Impact Statement for the Vernal Field Office Planning Area,* Vernal Field Office, Utah, Aug.

BLM, 2008i, *Record of Decision and Approved Resource Management Plan*, Rawlins District Office, Great Divide Resource Area, Wyo.

BLM 2008j, *Final Programmatic Environmental Impact Statement for Geothermal Leasing in the Western United States*, FES-08-44, Oct.

BLM, 2008k, *Record of Decision and Resource Management Plan Amendments for Geothermal Leasing in the Western United States*, Dec.

BLM, 2010, *Record of Decision for the Kemmerer Resource Management Plan and Rangeland Program Summary Document*, Kemmerer Resource Area, Rock Springs District, Wyo.

BLM and DOE (BLM and U.S. Department of Energy), 2010, *Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States,* DES 10-59, DOE/EIS-0403, Dec.

BLM and DOE, 2011, *Supplment to the Draft Programmatic Environmental Impact Statement for Solar Energy in Six Southwestern States*, DES 11-49, DOE/EIS-0403D-S, Oct.

DOE and DOI (U.S. Department of Energy and U.S. Department of the Interior), 2008, *West-Wide Energy Corridor Programmatic Environmental Impact Statement, Designation of Energy Corridors on Federal Land in the 11 Western States*, DOE/EIS-0386, Nov. Available at http://corridoreis.anl.gov/documents/index.cfm.

Green, G.N., 1992, *The Digital Geologic Map of Colorado in ARC/INFO Format*, U.S. Geological Survey, Open-File Report 92-0507, scale 1:500,000.

Green, G.N., and P.H. Drouillard, 1994, *The Digital Geologic Map of Wyoming in ARC/INFO Format*, U.S. Geological Survey, Open-File Report 94-0425, scale 1:500,000.

Hintze, L.F., et al., 2000, *Digital Geologic Map of Utah*, Utah Geological Survey, Map 179DM compact disc, scale 1:500,000.

Pitman, J.K., 1979, *Isopach, Structure Contour, and Resource Maps of the R-6 Oil Shale Zone, Green River Formation, Piceance Creek Basin, Colorado*, U.S. Geological Survey, Miscellaneous Field Investigations Map MF-1069.

Pitman, J.K., and R.C. Johnson, 1978, *Isopach, Structure Contour, and Resource Maps of the Mahogany Oil-Shale Zone, Green River Formation, Piceance Creek Basin, Colorado*, U.S. Geological Survey, Miscellaneous Field Investigations Map MF-958.

Pitman, J.K., et al., 1989, *Thickness, Oil-Yield, and Kriged Resource Estimates for the Eocene Green River Formation, Piceance Creek Basin, Colorado*, U.S. Geological Survey, Oil and Gas Chart OC-132.

Secretary of the Interior, 2010, *Renewable Energy Development by the Department of the Interior, Amendment No. 1 to Secretarial Order 3285*, Feb. 22. Available at http://elips.doi.gov/2 app_so/act_getfiles.cfm?order_number=3285A1.

USGS (U.S. Geological Survey), 1980a, *Argyle Canyon–Willow Creek, Utah Tar Sand Leasing Minutes No. 9*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980b, *Asphalt Ridge–Whiterocks and Vicinity, Utah Tar Sand Leasing Minutes No. 3*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980c, *Circle Cliffs East and West Flanks, Utah Tar Sand Leasing Minutes No. 5*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980d, *Hill Creek, Utah Tar Sand Leasing Minutes No. 6*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980e, *Pariette, Utah Tar Sand Leasing Minutes*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980f, *P.R. Spring, Utah Tar Sand Leasing Minutes*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980g, *Raven Ridge–Rim Rock and Vicinity, Utah Tar Sand Leasing Minutes No. 8*, Minutes of the Mineral Land Evaluation Committee, Nov. 10

USGS, 1980h, *San Rafael Swell, Utah Tar Sand Leasing Minutes No. 7*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980i, *Sunnyside and Vicinity, Utah Tar Sand Leasing Minutes No. 4*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980j, *Tar Sand Triangle, Utah Tar Sand Leasing Minutes No. 2*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980k, *White Canyon, Utah Tar Sand Leasing Minutes No. 11*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 2010a, *Oil Shale and Nahcolite Resources of the Piceance Basin, Colorado,* National Oil and Gas Assessment Project, Digital Data Series DDS–69–Y, U.S. Geological Survey Oil Shale Assessment Team.

USGS 2010b, *Oil Shale Resources of the Uinta Basin, Utah and Colorado*, National Oil and Gas Assessment Project, Digital Data Series DDS–69–BB, U.S. Geological Survey Oil Shale Assessment Team.

USGS, 2011, *Oil Shale Resources of the Eocene Green River Formation, Greater Green River Basin, Wyoming, Colorado, and Utah,* National Oil and Gas Assessment Project, Digital Data Series DDS–69–DD, U.S. Geological Survey Oil Shale Assessment Team

Wiig, S., 2006a, personal communication from Wiig (BLM Rock Springs Field Office, Wyo.) to P. Perlowitz (BLM Wyoming State Office, Cheyenne), June 13.

Wiig, S., 2006b, personal communication from Wiig (BLM Rock Springs Field Office, Wyo.) to K.P. Smith (Argonne National Laboratory, Lakewood, Colo.), June 27.

2 DESCRIPTIONS OF ALTERNATIVES

2.1 INTRODUCTION

This PEIS examines alternatives for designating public lands managed by the BLM as available or not available for application for future commercial leasing of both oil shale and tar sands resources. The phrase "available for application for leasing" is used above, and throughout the PEIS, rather than "available for leasing" to highlight that, unlike the BLM's practice with respect to oil and gas leasing, additional analysis, including but not limited to NEPA, the National Historic Preservation Act of 1966, as amended (NHPA), and the Endangered Species Act of 1973 (ESA), would be required prior to the issuance of any lease of oil shale or tar sands resources, even in areas designated as "available" through the planning process. For each of the resources, oil shale and tar sands, there are four alternatives analyzed in detail. Alternative 1 (the No Action Alternative) does not amend plans. Management prescriptions in existing plans are not modified. Alternatives 2, 3, and 4 describe different management approaches to amending RMPs to designate certain lands as being available, and certain lands as being not available, for application for future commercial leasing and development. The BLM's approach is designed to ensure that oil shale technologies can operate at economic and environmentally acceptable levels before the agency authorizes full-scale commercial leasing on public lands. Future oil shale and tar sands commercial development on public lands in Colorado, Utah, and Wyoming would be conducted pursuant to regulations applicable to these respective resources.

This chapter presents information on each of the oil shale and tar sands alternatives examined in this PEIS. Specifically, the following sections describe the existing requirements and BLM policies potentially applicable to oil shale and tar sands development, the oil shale and tar sands resources, the suite of technologies included in the scope of this PEIS, the constraints evaluated in each alternative, and the comparison of alternatives. In addition, this chapter discusses the alternatives and issues considered by the BLM in preparing this PEIS that were eliminated from detailed analysis or from further consideration at this time.

This PEIS analyses four alternatives: the No Action Alternative and three land allocation alternatives. Each alternative addresses both oil shale and tar sands resources. Since the resources lie in separate geographical areas and employ difference extraction and processing technologies, separate parallel discussions are presented for oil shale and tar sands. While oil shale and tar sands are discussed in separate sections, the four alternatives analyzed under each resource are defined in the same way with respect to land allocation considerations. Specifically, the types of land exclusions defining the alternatives are the same for each resource.

2.2 EXISTING STATUTORY REQUIREMENTS AND BLM POLICIES POTENTIALLY APPLICABLE TO OIL SHALE AND TAR SANDS DEVELOPMENT

Commercial leasing and development of oil shale or tar sands resources on public lands will be subject to existing federal, state, and local laws and regulatory requirements as well as

established BLM policies. The purpose of including the following information is to convey that management of public lands is subject to a wide array of requirements that are over and above decisions that will be made in the ROD for this PEIS. These requirements are not subject to decisions in the ROD but serve to provide context for those decisions.

2.2.1 Existing Relevant Statutory Requirements

This section discusses, in very general terms, the major laws, E.O.s, and policies that may provide environmental protection and compliance requirements for oil shale or tar sands leasing and development projects on public lands in Colorado, Utah, and Wyoming. Because these projects would vary on the basis of design, size, specific activities, and location, the requirements described here may not apply to all projects. Lists of specific E.O.s and federal and state laws are provided in Appendix D.

The BLM conducts its operations in accordance with FLPMA and with numerous statutes, regulations, and standards regarding environmental protection. In addition, E.O. 12088, "Federal Compliance with Pollution Control Standards" (U.S. President 1978), as amended by E.O. 13148, "Greening of Government through Leadership in Environmental Management" (U.S. President 2000), requires federal agencies (including the BLM) to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the Resource Conservation and Recovery Act of 1976 (RCRA), Toxic Substances Control Act of 1976 (TSCA), Clean Air Act of 1990 (CAA), Noise Control Act of 1972 (NCA), Clean Water Act of 1987 (CWA), and Safe Drinking Water Act of 1974 (SDWA). Other compliance requirements may include the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), hazardous material transportation laws, ecological resources requirements (e.g., ESA), and cultural and paleontological resources requirements (e.g., NHPA, the Native American Graves Repatriation and Protection Act of 1990, as amended [NAGRPA], the Archaeological Resources Protection Act of 1979, and the Paleontological Resources Preservation subtitle of the Omnibus Public Land Management Act of 2009).

In the Energy Policy Act of 2005, among many energy-related provisions, Section 369 titled the "Oil Shale, Tar Sands, and Other Strategic Unconventional Fuels Act," provided direction to the Secretary of the Interior to complete a PEIS for a commercial leasing program for oil shale and tar sands resources on public lands; publish a final regulation establishing a commercial leasing program; consult with the Governors of States with significant oil shale and tar sands resources on public lands, representatives of local governments in such states, interested Indian Tribes, and other interested persons, to determine the level of support and interest in the states in the development of tar sands and oil shale resources; and, if sufficient support and interest exists in a state, the Secretary may conduct a lease sale in that state under the commercial leasing program.

The MLA authorizes the Secretary of the Interior to lease deposits of oil shale and the surface of public lands containing the deposits, or lands adjacent thereto, as may be required for the extraction and reduction of leased minerals. It also authorizes the issuance of right-of-way (ROW) grants for oil and gas, synthetic fuels, and refined products gathering and distribution

pipelines and related facilities not already authorized through a lease. Under the MLA, the lease may not exceed 5,760 acres[1] and may be of an indeterminate period. The Secretary of the Interior may impose conditions on the lease, including requirements relative to methods of mining, prevention of waste, and productive development.

The BLM also conducts its operations in compliance with applicable land use laws, including the Wild and Scenic Rivers Act of 1968, the National Trails System Act of 1968, and the Wilderness Act of 1964. In addition, any leasing of public lands for oil shale or tar sands development that may impinge on NPS lands would require the BLM to analyze potential impacts on the park lands, including the potential to impair park resources addressed in the National Park Service Organic Act of 1916. Under current regulations, issuance of combined hydrocarbon leases within units of the NPS shall be allowed only where mineral leasing is permitted by law, where the lands are open to mineral resource disposition in accordance with any applicable Bureau of Ocean Energy Management Plan, and the Regional Director of the NPS finds that there will be no resulting significant adverse impacts on the resources and administration of the unit or other contiguous units of the NPS.

Several other land use laws may guide development of a leasing plan for commercial oil shale or tar sands development. As discussed in Chapter 1, the BLM has authority pursuant to FLPMA, the Federal Land Exchange Facilitation Act of 1994, and the Federal Land Transaction Facilitation Act of 2000 to exchange public land or interests in it for nonfederal land or interests when the exchange serves the public good.

Oil shale and tar sands development projects may require ROWs on or across public land for project facilities. A ROW grant is the authorization to use a particular parcel of public land for specific facilities for a definite time period. FLPMA authorizes the BLM to issue ROW grants for uses such as roads and electrical power generation, transmission, and distribution systems. The MLA authorizes the agency to issue ROW grants for oil and gas gathering and distribution pipelines and related facilities not already authorized through a lease, and oil and natural gas transmission pipelines and related facilities. ROW grants carry conditions that require compliance with applicable environmental protection standards.

State and county laws and regulations also are applicable to oil shale or tar sands development projects to the extent consistent with federal law. In some cases, states have federally approved regulatory programs that meet or exceed the environmental protections provided by federal statutes and regulations (such as those under the CWA). States and counties also have developed laws to address concerns specific to their locations and resources with which federally approved projects must generally comply.

The potentially applicable laws have been divided into general categories, as described alphabetically below. Although the following descriptions often cite federal laws, state and county laws can also fall into these categories. Appendix D provides a list of federal, state, and county laws and E.O.s by category.

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[1] The acreage limit was increased from 5,120 acres by amendment of the MLA in Section 369 (i)(1) of the Energy Policy Act of 2005.

- *Air quality.* Air emissions from a development project are subject to the CAA, as amended. The CAA provides that each state must develop and submit for approval to the U.S. Environmental Protection Agency (EPA) a State Implementation Plan (SIP) for controlling air pollution and air quality in that state, and that each state must develop its own regulations to monitor, permit, and control air emissions within its boundaries. Under Section 112(r) of the CAA, owners and operators of facilities that produce, process, handle, or store specific hazardous substances above threshold quantities must meet certain requirements for planning and reporting and risk management planning requirements. Although the States of Colorado, Utah, and Wyoming each administer their own SIPs, the EPA has retained regulatory primacy over air quality within the boundaries of the Uintah and Ouray Reservation.

- *Cultural resources.* Cultural resources that may be affected by federal undertakings are subject to the requirements of various laws, regulations, and policies for identification and consideration in consultation with tribal, state, and/or federal entities, and mitigation actions may be required. Under the auspices of the 1997 national Programmatic Agreement (PA) and individual state protocols, the BLM has an agency-specific process for complying with Section 106 of the NHPA.

- *Energy projects.* Project operations and facilities may require construction of facilities such as pipelines, gathering lines, transmission lines, or generation facilities. Depending on the nature of these facilities, siting will be subject to all applicable legal requirements.

- *Floodplains and wetlands.* The locations of project facilities will be subject to statutory requirements and regulations for protection of wetlands or floodplains, such as Section 404 of the CWA.

- *Groundwater, drinking water, and water rights.* The provision of drinking water from wells or surface water to a nontransient noncommunity water system at project facilities would require compliance with the SDWA. In addition, the withdrawal of surface or groundwater for industrial or drinking water purposes may require state and/or local approvals or permits.

- *Hazardous materials.* Hazardous materials may be used in the construction and operation of a project. Storage and use of fuels, petroleum, oils, lubricants, and other hazardous materials at approved project facilities are subject to numerous federal and state regulations.

- *Hazardous waste and polychlorinated biphenyls (PCBs).* Hazardous wastes (e.g., used solvents and paints) generated by a project must be accumulated, collected, transported, and disposed of in accordance with RCRA. If PCBs are used during the construction and operation of a project, they would have to be managed in accordance with the TSCA.

- *Noise.* The EPA issued guidelines for outdoor noise levels that are consistent with the protection of human health and welfare against hearing loss, annoyance, and activity interference (EPA 1974). Such guidelines state that annoyance and undue interference with activity will not occur if outdoor levels of noise are maintained at an energy equivalent of 55 decibels (dB). However, these levels are not to be construed as legally enforceable standards at this time.

- *Paleontological resources.* The new authority for the management, preservation, and protection of paleontological resources on the National System of Public Lands is the Paleontological Resources Preservation subtitle of the Omnibus Public Land Management Act of 2009 (16 USC 470aaa et seq.). The Act requires that (1) paleontological resources collected under a permit remain the property of the United States to be preserved for the public and curated in an approved repository; (2) the nature and location of paleontological resources be kept confidential to protect them from theft and vandalism; and (3) civil and criminal penalties, including fines and imprisonment, be imposed when theft and vandalism to publicly owned paleontological resources occur. Paleontological resources on public lands will continue to be protected under FLPMA for mitigation purposes. Criminal and civil penalties for theft, vandalism, and other charges related to damage, destruction, or trafficking of paleontological resources are now covered under 16 USC 470aaa-5 to 470aaa-7. Supplementary counts may still be issued for Theft of Government property under 16 USC 641 and/or for Destruction of Government Property (18 USC 1361). Other federal acts, such as the Federal Cave Resources Protection Act and the Archaeological Resources Protection Act, protect paleontological resources found in significant caves and/or in association with archaeological resources. Paleontological resources found in context with archaeological resources are protected as archaeological resources.

- *Pesticides and noxious weeds.* Pesticide application during the construction and operation of a project must comply with the Federal Insecticide, Fungicide, and Rodenticide Act of 1974 and equivalent state requirements. In addition, sites will be subject to federal provisions to control noxious weeds and invasive species and may be subject to regulations governing state-established control areas.

- *Solid wastes.* Solid wastes generated during the construction, operation, and decommissioning of a project must be managed in accordance with the Solid Waste Disposal Act of 1976 and state and local requirements for solid waste accumulation, collection, transportation, and disposal.

- *Source water protection.* Under Part C of the SDWA, Protection of Underground Sources of Drinking Water, each state is to establish a wellhead protection program to delineate wellhead protection areas, identify potential

sources of contamination, and establish control measures to prevent contamination of drinking water sources. If hazardous chemicals or materials are used during the construction or operation of a project that is located within a wellhead protection area, reporting or control measures may apply.

- *Water bodies and wastewater.* The discharge of wastewater (e.g., sanitary wastewater treatment systems or rinse/test waters) or the discharge of spent shale leachate into waters of the United States or waters of a state will require a National Pollutant Discharge Elimination System (NPDES) permit or the state equivalent. According to administrative and judicial interpretation, the scope of the federal CWA jurisdiction over waters of the United States depends on technical, site-specific factors. Regulated bodies of water could include, but are not limited to, interstate and intrastate lakes, rivers, and streams, and certain wetlands, playa lakes, prairie potholes, mudflats, intermittent streams, and wet meadows. In addition, the CWA requires an NPDES permit or the state equivalent for certain stormwater discharges. Spill prevention, control, and countermeasure plans may also be required to prevent oil spills from reaching regulated waters, adjoining shorelines, intermittent streams, or wet meadows, but only if these are hydrologically connected to the navigable waters of the United States. States may have their own planning requirements for other waters. Discharges of dredged or fill material into waters of the United States or any work in, over, or under regulated waters will require a Section 404 or Section 410 permit, respectively, from the U.S. Army Corps of Engineers (USACE).

- *Water quality*. The EPA enacted a regulation in December 1974 that set forth a basinwide salinity control policy for the Colorado River Basin. In 1975, the Colorado River Basin Salinity Control Forum (CRBSCF) proposed, the Basin States adopted, and the EPA approved water quality standards to control salinity increases in the Colorado River. These standards, including the numeric criteria and plan of implementation, are to be reviewed every 3 years. Federal, state, and Tribal water quality standards may also be applicable.

- *Ecological resources.* Among the BLM's land management objectives are protection and improvement of habitat for all federally listed species, BLM-designated sensitive species (i.e., the list published by the BLM state office of species occurring on public lands whose populations or habitats are rare or in significant decline), state-listed species, and wild horse and burro herds. The BLM evaluates all projects and activities occurring on public lands to ensure that they will not contribute to the need to list species as threatened or endangered.

In addition to these categories, the construction and operation of an oil shale or tar sands development project on public land with overlapping valid existing mining claims in place must not materially interfere with the mining claimants' rights to mine, remove, or sell the minerals from the claim (30 USC 26). Projects may also be subject to the health and safety standards

of the Federal Mine Safety and Health Act of 1977 and the Occupational Safety and Health Act of 1970.

Requirements to consider impacts of leasing public land for oil shale or tar sands development on local populations may fall under several E.O.s, including E.O. 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (U.S. President 1994), and E.O. 13045, "Protection of Children from Environmental Health Risks and Safety Risks" (U.S. President 1997), depending on the activities, location, and other circumstances of the lease.

2.2.2 Existing Relevant BLM Policies and Mitigation Guidance

In September 2008, the BLM issued a Proposed Plan Amendments and Final OSTS PEIS analyzing the environmental and socioeconomic impacts of amending 12 land use plans in Colorado, Utah and Wyoming to designate public lands administered by the BLM as available for application for commercial leasing for oil shale or tar sands development (BLM 2008a). The November 17, 2008, ROD (BLM 2008b) that followed this PEIS adopted the proposed land use amendments reflecting the allocation decisions analyzed in the 2008 OSTS PEIS. These land allocation decisions, which are currently in effect, were challenged in a lawsuit brought by a coalition of environmental interests in January 2009. As part of a settlement agreement to the lawsuit and in light of new information that has emerged since the 2008 OSTS PEIS was prepared, the BLM has decided to take a fresh look at the land allocations analyzed in the 2008 OSTS PEIS and to consider excluding certain lands from future leasing of oil shale and tar sands resources.

As noted in Chapter 1, the following decisions from the 2008 OSTS PEIS ROD will be carried forward through this planning process and would be applicable regardless of the alternative eventually selected for adoption: the requirement for future NEPA analyses and consultation activities to occur prior to any decision to lease and/or develop oil shale and tar sands resources; and the specific decision that the BLM will consider and give priority to the use of land exchanges to facilitate commercial oil shale development pursuant to Section 369(n) of the Energy Policy Act of 2005.

The 2008 OSTS PEIS was prepared simultaneously with the rulemaking process that concluded with promulgation of the 2008 oil shale regulations in November 2008 (73 FR 69469) (Nov. 18, 2008); codified at 43 CFR Parts 3900–3930). The 2008 OSTS PEIS, however, did not analyze those regulations. The regulations were analyzed through a separate NEPA process. Thus the 2008 OSTS PEIS did not pre-judge or try to predict the final regulations or any impact they might have on development of oil shale resources. The final regulations remain in effect, although the Department will be proposing some amendments to them in a separate rulemaking proceeding. Those proposed amendments will be analyzed in a separate document under NEPA and will not be analyzed here.

Similarly, there are regulations in place that govern the leasing and development of tar sands. As explained in Chapter 1, the Combined Hydrocarbon Leasing Act of 1981 (PL 97-78)

amended the MLA to authorize the Secretary to issue CHLs in areas containing substantial deposits of tar sands, which were to be designated as STSAs. This Act further specified that a CHL was the only type of lease that could be offered in these STSAs, provided for the conversion of existing oil and gas leases or tar sands claims in these areas to CHLs, and established the maximum lease size as 5,120 acres. The CHL Act defined oil as all nongaseous hydrocarbons except coal, oil shale, gilsonite, and other vein-type solid hydrocarbons. Eleven STSAs were designated in 1980 and 1981. The BLM published regulations implementing the leasing provisions of this Act in February 1983 at 43 CFR Part 3140. Subsequently, the BLM prepared the Utah Combined Hydrocarbon Leasing EIS (BLM 1984). Tar sands resources located outside of these STSAs were not subject to the requirements of 43 CFR Part 3140 and are available for development under oil and gas leases.

Under the authority of the Combined Hydrocarbon Leasing Act, six CHLs were issued in the mid-1980s within the Pariette and P.R. Spring STSAs in the Vernal Field Office; these leases remain in existence. Also in the mid-1980s, a number of operators holding oil and gas leases or tar sands claims within the designated STSAs applied to convert their leases to CHLs. In most instances, the conversion of these leases has not been completed; thus a number of pending conversion applications remain within the study area, specifically within the Circle Cliffs, Tar Sand Triangle, and P.R. Spring STSAs. The BLM is currently engaged in adjudication of these applications.

On May 18, 2006, pursuant to Section 350 of the Energy Policy Act of 2005, which amended the MLA to allow separate oil and gas leases and tar sands leases in designated STSAs, the BLM issued a final rule on leasing in STSAs (71 FR 28779, codified at 43 CFR Subpart 3141). The final rule authorizes the BLM to issue separate leases for exploration for and extraction of tar sands, separate leases for exploration for and development of oil and gas, and separate leases for CHLs within designated STSAs. Under the rule, all three types of leases would have primary terms of 10 years; CHLs and oil and gas leases would remain in effect as long thereafter as oil or gas is produced in commercial quantities; tar sands leases would remain in effect after the 10-year term as long as tar sands are produced in commercial quantities. The final rule increases the maximum acreage of CHLs or tar sands leases in a STSA from 5,120 to 5,760 acres, establishes the minimum acceptable bid for tar sands leases at $2.00 per acre, and requires that tar sands leases be issued by competitive processes only. In addition, under the final rule, leasing STSAs in NPS units is allowed only where mineral leasing is permitted by law and where the lands are open to mineral resource disposition in accordance with any applicable Minerals Management Plan. The NPS Regional Director also must find that leasing within an NPS unit would not result in any significant adverse impacts on the NPS unit or any contiguous unit.

Decisions in the ROD resulting from this PEIS regarding the availability of lands within the STSAs for future commercial leasing will not affect or be affected by the requirements established for tar sands leasing in the regulations.

In addition to these regulations and policies, the BLM has developed many program-specific policies and guidance documents that establish requirements that may be relevant and/or applicable to oil shale or tar sands development. For example, from 1968 to 1989, the Office of

the Secretary imposed stipulations on oil and gas leases for lands in oil shale areas in Colorado, Utah, and Wyoming (DOI 1968). These policies and guidance documents exist in a variety of forms, including BLM plans, manuals, handbooks, instruction memoranda, technical references, BMPs, standards, directives, and other such documents. The applicability of specific policies and guidance documents is discussed to varying degrees in this PEIS but is best assessed at the project-specific level.

Besides the provisions of the 2008 OSTS PEIS ROD and the regulations governing, respectively, the oil shale and tar sands programs, many elements of existing BLM policies, specifically focused on other resources, establish requirements that are relevant and applicable to these types of development projects. Examples of policies that will be applicable to oil shale or tar sands development include BLM policies regarding the management of sensitive species and visual, cultural, and paleontological resources and BLM's responsibilities for tribal consultation.

Similarly, other existing BLM guidance more general in scope may be applicable to oil shale and tar sands development, because this guidance addresses environmental issues that are relevant to such development and may provide appropriate mitigation measures. Examples of those topics include land use planning, NEPA, oil and gas development, pipeline construction and waterway crossings, road construction and maintenance, wildlife management, wild horse and burro herd management, ACECs, hazardous materials and waste management, pesticide use and integrated pest management, cultural resource management, Tribal consultations, visual resource management, and occupational health and safety. A comprehensive review of these BLM program-specific mitigation policies is beyond the scope of this PEIS, although discussion of many of these policies is included in the impact analyses sections. Readers are advised to obtain the complete guidance documents if they seek more information. Electronic copies of some of the BLM directives, manuals, and handbooks are available at http://www.blm.gov/nhp/efoia/.

2.2.3 Management of BLM-Administered Lands

The BLM manages public lands within the affected field offices for a variety of land uses and values, including, among others, recreation, mining, oil and gas development, livestock grazing, wild horse and burro herd management wildlife resources, visual resources, LWC, communication sites, and ROW corridors (e.g., roads, pipelines, and transmission lines). BLM-administered lands are managed within a framework of numerous laws, the most comprehensive of which is FLPMA (43 USC 1701 et seq.). Under FLPMA, the BLM manages the public lands by using principles of multiple use and sustained yield to provide for the protection and the use of the myriad resources found on the public lands. In accordance with the requirements of FLPMA, the BLM prepares RMPs to identify the resources within each planning area and to establish land use allocations, management goals, and prescriptions for the planning area. The RMPs are prepared to be consistent with the plans of state and local governments to the maximum extent feasible and consistent with federal law. These plans are developed with significant public involvement and are reviewed by the governors of each state for consistency with state and local planning objectives. Under FLPMA, the BLM is required to maintain,

amend, and revise its RMPs to ensure that they reflect the current conditions and management goals within the planning area.

FLPMA, and in many cases specific authorizing legislation or proclamations, guides the BLM in its management of lands included in the NLCS. The NLCS lands include NCAs, National Monuments, Wilderness Areas, WSAs, WSRs, and National Historic and Scenic Trails. Other conservation designations within the NLCS are Instant Study Areas (ISAs), Forest Reserves, National Recreation Areas (NRAs), Research Natural Areas, and Outstanding Natural Areas.

FLPMA directs the BLM to give priority to the designation of ACECs. Designated ACECs include public lands where special management attention and direction are needed to protect and prevent irreparable damage to important historic, cultural, and scenic values, fish, or wildlife resources or other natural systems or processes. ACECs may also be used to protect human life and safety from natural hazards. The BLM designates ACECs through land use plans that outline management objectives and prescriptions for each ACEC. Table 2.2.3-1 identifies all of the existing ACECs that lie within oil shale and tar sands areas.

Wilderness Areas are designated by Congress as part of the National Wilderness Preservation System to ensure preservation and protection of their natural conditions. They comprise at least 5,000 acres or more in size (or of sufficient size to make administration as wilderness practicable); offer outstanding opportunities for solitude or primitive and unconfined types of recreation; and may contain ecological, geological, or other features that have scientific, scenic, or historical value. WSAs are areas identified by a federal land management agency (i.e., the BLM, USFS, NPS, or USFWS) as having wilderness characteristics, thus making them worthy of consideration by Congress for wilderness designation. While Congress considers whether to designate the WSAs as permanent Wilderness Areas, the federal agency managing the WSA does so in a manner to prevent impairment of the area's suitability for wilderness designation.

Since WSAs were established in the late 1970s and 1980s, designation of wilderness lands has been extensively debated, and additional BLM lands have been identified by the public as having wilderness characteristics. In 1996, the Secretary of the Interior directed the BLM in Utah to evaluate such lands to determine whether they possess wilderness characteristics. According to the BLM policy, indicators of an area's naturalness include the extent of landscape modifications, the presence of native vegetation communities, and the connectivity of habitats. Outstanding opportunities for solitude or primitive and unconfined types of recreation may be experienced when the sights, sounds, and evidence of other people are rare or infrequent; in locations where visitors can be isolated, alone, or secluded from others; where the use of the area is through nonmotorized, nonmechanical means; and where no or minimally developed recreation facilities are encountered. A number of areas in the PEIS study area have been recognized by the BLM as having wilderness characteristics. Processes are underway in some of the BLM field offices where such lands have been identified to determine appropriate management requirements, if any, for these areas. For the most part, decisions regarding management of these areas will be made at the field office level as part of the local land use planning process, or as a separate plan amendment, not as part of this PEIS; however, two of the

TABLE 2.2.3-1 Existing ACECs Intersecting Oil Shale or Tar Sands Areas

ACEC	Field Office(s)	ACEC Acres Total	Within Oil Shale Areas	Within STSAs
Colorado				
Duck Creek	White River	3,426	3,426	0
Dudley Bluffs	White River	1,628	1,628	0
East Fork Parachute Creek	Colorado River Valley	6,566	1,289	0
Ryan Gulch	White River	1,436	1436	0
Trapper Creek	Colorado River Valley, White River	2,845	1,419	0
Trapper Creek/Northwater Creek	Colorado River Valley, White River	1,962	1,592	0
Utah				
Copper Globe	Price	124	0	124
I-70 Scenic Highway	Price	33,094	0	3,240
Lears Canyon	Vernal	1,378	0	890
Lower Green River	Vernal	9,353	7,677	0
Nine Mile Canyon	Vernal and Price	74,368	538	22,335
Pariette Wetlands	Vernal	10,657	6,533	2,261
San Rafael Canyon	Price	15,165	0	0
Cottonwood-Diamond Watershed	Moab	35,080	0	3
Lucky Strike	Price	892	0	575
Shepard's End	Price	3	0	3
Wild Horse Canyon	Price	710	0	122
San Rafael Reef	Price	73,229	0	3,807
Temple Mountain	Price	788	0	788
Wyoming				
Greater Red Creek	Rock Springs	175,207	44,847	0
Greater Sand Dunes	Rock Springs	41,648	391	0
Pine Springs	Rock Springs	6,056	6,056	0
Special Status Plant Species	Rock Springs, Kemmerer	1,177	71	0
White Mountain Petroglyphs	Rock Springs	22	22	0
	(All)	496,811	76,924	35,726

alternatives considered in detail in this PEIS include provisions excluding from future consideration of oil shale and tar sands leasing and development any lands identified by the BLM as having wilderness characteristics.

Under Section 201 of FLPMA, the BLM is required to maintain an inventory of public land resources, including LWC.[2] Since the original wilderness inventory is more than 30 years

[2] Wilderness characteristics include: size—roadless areas of at least 5,000 acres of public lands or are of a manageable size; naturalness—the land generally appears to have been affected primarily by the forces of nature; and opportunities—outstanding opportunities for solitude or primitive and unconfined types of recreation.

old, the BLM field offices periodically update the original inventory to identify where LWC are currently found. As RMPs are revised, the BLM is considering whether or not LWC within a particular RMP area will be managed to protect those wilderness characteristics or if those lands will be committed to other uses. The status of the wilderness characteristics inventory for the portion of each field office within the oil shale and tar sands study area is included in Section 3.1.1 of this PEIS.

A river or river section may be designated as a WSR by Congress or the Secretary of the Interior under the authority of the Wild and Scenic Rivers Act of 1968. Land management agencies conduct inventories of rivers and streams within their jurisdictions and make recommendations to Congress regarding the potential inclusion of suitable rivers into the WSR system as part of their land use planning process. These special areas are managed to protect outstanding scenic, recreational, geologic, fish and wildlife, historic, cultural, or other values, and to preserve the river or river section in its free-flowing condition. WSR boundaries are established to include a corridor of land along either side of the river as determined to be appropriate for protection of the river's values. The law recognizes three classes of rivers: wild, scenic, and recreational. It is the BLM's policy to manage potentially eligible and suitable[3] WSRs in a manner to prevent impairment of the river's suitability for WSR designation until Congress or the Secretary makes a final determination regarding the river's status. During this interim period, a corridor extending at least 0.25 mi from the "high water" mark on each bank of the river is established.

National Historic and Scenic Trails are designated by Congress under the National Trails System Act of 1968. National Historic Trails follow as closely as possible the original trails or routes of travel with national historical significance. Such designation identifies and protects historic routes and their historic remnants and artifacts for public use and enjoyment. National Scenic Trails are extended trails that offer maximum outdoor recreational potential and provide enjoyment of the various qualities (e.g., scenic, historical, natural, and cultural) in the areas through which they pass.

BLM-administered lands support a wide array of recreational activities important to growing numbers of local, regional, and national users. While unstructured or "dispersed" recreation uses are common on public lands, developed recreation sites, Special Recreation Management Areas (SRMAs), and off-highway vehicle (OHV) areas are all use areas found within the PEIS study area.

A significant portion of the public lands within the most geologically prospective oil shale area is undergoing development of its oil and gas resources. Conflicts in development among resources (e.g., oil shale or tar sands and oil and gas) may occur. Generally, the concept of prior existing rights would prevail, except in some instances when existing stipulations would

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[3] As part of recent revisions of a number of land use plans, WSR inventories have been undertaken. Where a river or river segment is found to be "eligible" for inclusion in the WSR system as part of one of these inventories, the BLM's Land Use Planning Handbook (H-1601-1) (BLM 2005) directs the BLM to protect the lands along the eligible segment until a "suitability" determination has been made as part of the land use planning process. If the river or river segment is found to be "non-suitable," the lands along the river then would be available for other uses.

take precedence; however, it is the BLM's policy to optimize recovery of natural resources in an effort to secure the maximum return to the public in revenue and energy production; prevent avoidable waste of the public's resources utilizing authority under existing statutes, regulations, and lease terms; honor the rights of lessees, subject to the terms of existing leases and sound principles of resource conservation; and protect public health and safety and mitigate environmental impacts. Conflicts among competing resource uses are generally considered and resolved when processing potential leasing actions or evaluating requests for approvals of plans of development (see also Section 4.2.1.1).

As discussed in Chapter 1, Section 369(n) of the Energy Policy Act of 2005 required the Secretary to consider and give priority to the use of land exchanges to facilitate the recovery of unconventional fuels. The Act dictates that any land exchange undertaken shall be implemented in accordance with Section 206 of FLPMA. The BLM's policy for land exchanges under Section 206 recognizes that a land exchange is a common-sense tool that enables the BLM and other landowners to improve land management and consolidate ownership. Therefore, where it can be demonstrated that the public interest will be well served, land exchanges may be considered on a case-by-case basis when the result will consolidate ownership and improve management of natural resources. Land exchanges, however, are not completed on an acre-for-acre basis, but instead are completed on an equal-value basis. One of the more challenging aspects of the land exchange process is developing an exchange proposal where the appraised values of the federal and nonfederal lands are equal. Given the complexities of achieving equal-value land exchanges, especially recognizing the difficulty in valuing a commodity like oil shale or tar sands, a viable exchange proposal may be difficult to achieve. The initial basis for considering land exchange opportunities lies within existing land use plans.

2.3 OIL SHALE

Oil shale is a term used to cover a wide range of fine-grained, organic-rich sedimentary rocks. Oil shale does not contain liquid hydrocarbons or petroleum as such but organic matter derived mainly from aquatic organisms. This organic matter, kerogen, may be converted to oil through destructive distillation or exposure to heat. The most prospective oil shale deposits in the United States are contained within sedimentary deposits of the Green River Formation in the greater Green River Basin (including Fossil Basin and Washakie Basin) in southwestern Wyoming and northwestern Colorado, the Piceance Basin in northwestern Colorado, and the Uinta Basin in northeastern Utah. As discussed in Section 1.2, the analyses in this PEIS focus on the most geologically prospective oil shale resources in these basins (i.e., the oil shale study area) shown in Figure 2.3-1. In Colorado and Utah, these are defined as those deposits that are expected to yield 25 gal/ton or more of shale oil and that are 25 ft thick or greater. In Wyoming, where the oil shale resource is not of as high a quality as it is in Colorado and Utah, the most geologically prospective oil shale resources are those deposits that yield 15 gal/ton or more of shale oil and that are 15 ft thick or greater. Figure 2.3-1 shows the Green River Formation basins and the most geologically prospective oil shale resources within those basins. Table 2.3-1 lists the total size in acres of the Green River Formation basins and the most geologically prospective oil shale resources by state, along with the total number of acres of BLM-administered and split estate lands within the most geologically prospective area within each state.

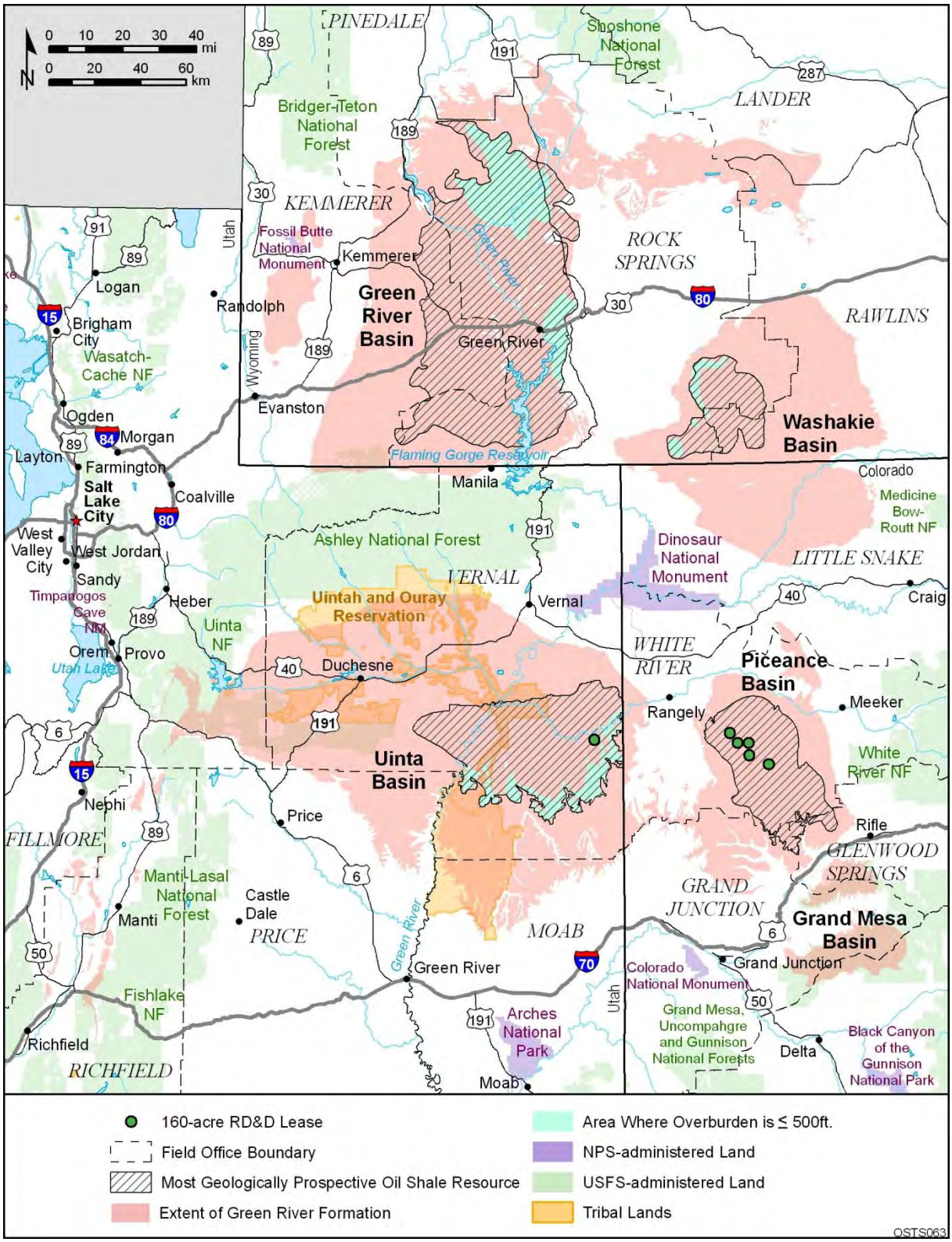

FIGURE 2.3-1 Green River Formation Basins in Colorado, Utah, and Wyoming; the Most Geologically Prospective Oil Shale Resources; the Areas Where the Overburden above the Oil Shale Resources Is ≤500 ft; and Locations of the Six RD&D Projects

TABLE 2.3-1 Total Size in Acres of the Green River Formation Basins, Most Geologically Prospective Oil Shale Areas, and Acres of BLM-Administered and Split Estate Lands within the Most Geologically Prospective Areas in Each State[a,b]

State	Total Size of Basin	Total Size of Most Geologically Prospective Area	Total BLM-Administered Lands in Most Geologically Prospective Area	Total Split Estate Lands in Most Geologically Prospective Area
Colorado				
Piceance Basin	1,185,700	503,342	307,165	39,886
Utah				
Uinta Basin[c]	2,977,900	840,572	560,870	76,820
Wyoming				
Green River and Washakie Basins	4,506,200	2,194,483	1,244,162	38,219
Total	8,669,800	3,538,297	2,112,197	154,926

[a] Totals may not be exact because of rounding. These estimates were derived from geographic information system (GIS) data compiled for the PEIS analyses. The GIS data may contain errors; therefore, these estimates should be considered to be only representative of the size of the oil shale resources and the distribution of BLM-administered and split estate lands.

[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] The split estate lands in the Hill Creek STSA include 57,705 acres of split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation on which the surface rights are owned by the Ute Indian Tribe.

Oil shale is actually the rock marlstone, which contains kerogen, a precursor to oil. The kerogen must be heated to more than 750ºF to convert it into oil because it was never buried deeply enough for nature to convert the kerogen to oil**.** Oil shale should not be confused with shale oil. In shale oil, the strata were buried deeply enough that the temperature was sufficiently high to naturally convert the kerogen into oil. Currently, a major exploration effort is being carried out in Colorado to produce oil from the Niobrara shales, primarily in eastern Colorado. In shale oil plays such as the Bakken in North Dakota and Montana, the objective is to find brittle layers in the shale, drill horizontal holes along those brittle layers, artificially fracture the rock, and produce the resulting oil.

Currently, there is no commercial production of oil from oil shale being undertaken in the United States. However, several companies, including Red Leaf Resources and Enefit American

Oil Company, are planning commercial production in the near future in the Unita Basin. Considerable interest exists, however, as reflected by the numerous R&D efforts underway, including the BLM's ongoing oil shale RD&D program. As discussed in Section 1.4.1, under the BLM's oil shale RD&D program, five RD&D leases have been issued in the Piceance Basin of Colorado (one each awarded to Chevron Shale Oil Company and American Shale Oil, LLC, and three awarded to Shell Frontier Oil & Gas), and one RD&D lease has been issued in the Uinta Basin, Utah (awarded to OSEC, which was purchased by Enefit American Oil in 2011). The locations of the six RD&D projects are shown in Figure 2.3-1 and, in greater detail, in Figure 2.3-2. In the PEIS, these leases are recognized as prior existing rights, and development will proceed under the lease terms under all alternatives being considered. For purposes of this analysis, it was assumed that all of the sites could reach full commercial development and may utilize the full acreage available to them under their leases. The very limited decisions being considered in this PEIS regarding the areas included in the RD&D leases are described in Sections 2.3.2 and 2.3.3. Table 2.3-2 briefly describes the six RD&D projects; more detailed descriptions of these projects are contained in Appendix A.

A second round of solicitations of interest in RD&D leases was issued by the BLM on November 3, 2009. Three nomination packages were submitted; all three were selected for further consideration, including preparation of EAs under NEPA. The projects that were selected include two projects in the Piceance Basin, Colorado (one from ExxonMobil Exploration Company and one from Natural Soda Holdings Inc.), and one project in the Uintah Basin, Utah, submitted by Aurasource. These projects are undergoing NEPA analysis. Table 2.3-2 briefly describes the three new RD&D projects; more detailed descriptions of these projects are provided in Appendix A.

The BLM, under the direction of the Energy Policy Act of 2005, completed regulations that would be used to authorize commercial oil shale leasing. The BLM published a final rule for the management of a commercial oil shale leasing program in the *Federal Register* on November 18, 2008. In 2009, a consortium of plaintiffs filed two lawsuits in the federal District of Colorado, each now captioned *CEC v. Salazar*, against the BLM and the Department of Interior. The first suit challenged the BLM's 2008 oil shale regulations. This suit was settled. Under the settlement agreement filed with the U.S. District Court in Colorado, the BLM agreed to purpose changes to the rule and to publish a final rule by November 18, 2012.

2.3.1 Potential Commercial Oil Shale Development Technologies

This section briefly describes the oil shale development technologies that the BLM believes may be used commercially in the 20-year time frame assessed in this PEIS. The BLM has chosen a 20-year time frame because that is the customary time frame used in resource management planning cycles. Appendix A provides a more detailed discussion of potential technologies that may be used over the next 20 years, along with a brief history of oil shale development. Information presented in this section and Appendix A regarding technologies that could be used is taken from the best available published data. Because commercial oil shale development technologies are still largely in an R&D phase, many details regarding the specific technologies that may be used in the future to produce oil from oil shale are unknown. In the

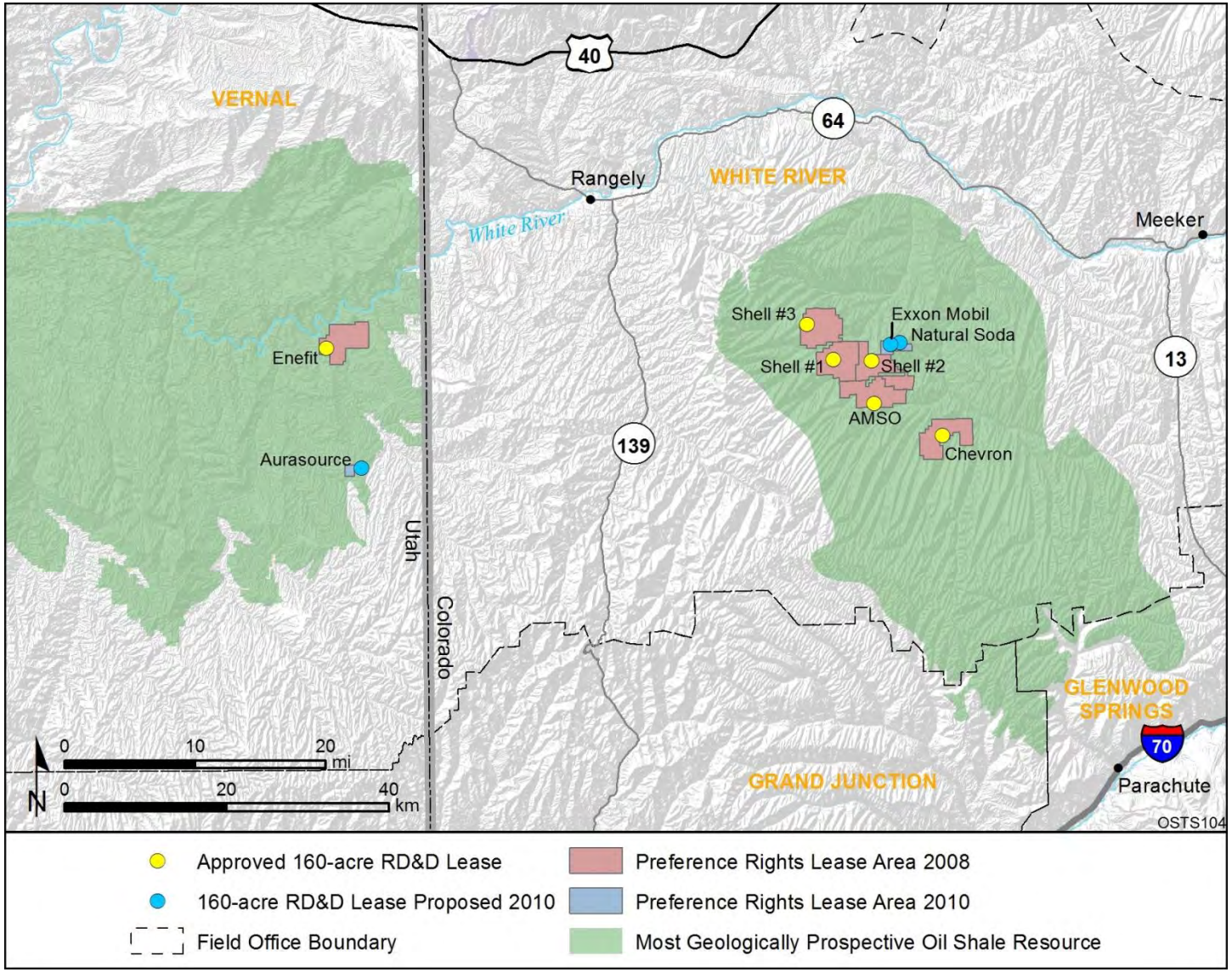

FIGURE 2.3-2 Locations of the Six RD&D Tracts and Associated PRLAs

TABLE 2.3-2 Summary Information for the Six Existing and Three Proposed Oil Shale RD&D Projects[a]

Project[b]	Technology	Design Basis for Facility (bbl/day)[c]	Total Annual Production (thousand bbl/yr)	Total Acreage Impacted
First Round				
AMSO	In situ processes	240	87.6	90
Chevron	In situ processes	20–50	7.3–18.25	100
Enefit[d]	Underground mine with surface retort	60–3,900	23–1,400	120
Shell Project 1	In situ conversion process (ICP)	500–1,500	180–550	160
Shell Project 2	Two-step ICP	500–1,500	180–550	160
Shell Project 3	Electric ICP	500–1,500	180–550	160
Second Round				
Aurasource	NA[e]	NA	NA	160
ExxonMobil[f]	In situ processes	400–700	NA	160
Natural Soda[f]	In situ processes	NA	NA	160

[a] RD&D projects in Round 1 are current approved projects. RD&D projects in Round 2 are pending proposed projects as of 2010.

[b] Chevron = Chevron U.S.A., Inc.; AMSO = American Shale Oil LLC; Enefit = Enefit American Oil; ExxonMobil = ExxonMobil Exploration Company; Natural Soda = Natural Soda Holdings Inc.; Shell = Shell Frontier Oil and Gas.

[c] bbl = barrel; 1 bbl oil = 42 gal.

[d] Enefit (formerly OSEC) is currently proposing to build a 57,000-bbl/day facility.

[e] NA = data not available.

[f] Sources: ExxonMobil 2011; Natural Soda Holdings 2011).

absence of reasonably complete information about the technologies that may be deployed, a number of assumptions have been made. These assumptions are discussed in Section 4.1.

Development of oil shale resources occurs in three major steps: (1) recovery or extraction from the natural setting, (2) processing to separate organic and inorganic constituents, and (3) upgrading the organic components in anticipation of further refining into conventional fuels. The physical and chemical features of oil shale deposits and other circumstantial factors associated with their deposition dictate the most appropriate development schemes. Typical development schemes always involve each of the above major steps, although many different combinations of these steps are possible, and many interim steps may also be necessary. In addition, all oil shale development projects also must stabilize and properly dispose of wastes and by-products. For mining technologies, spent shale is a significant waste management concern.

The recovery or extraction technologies can be divided into direct and indirect recovery methods. Direct recovery methods include both surface mining and underground mining

technologies wherein the oil shale is removed from its physical location for processing for recovery of the hydrocarbon constituents. Indirect recovery methods recover the hydrocarbon constituents from the oil shale without requiring the excavation of the oil shale inorganic (rock) matrix. Such processes can include in situ processing technologies, as well as some other enhanced oil recovery technologies developed primarily for the recovery of conventional oil and gas, in varying combinations that may be used in commercial oil shale development. Appendix A provides a detailed discussion of each of the individual technologies and some of the possible combinations of technologies that may be used in commercial oil shale development.

Processing technologies to separate the organic and inorganic constituents typically use retorting technologies that apply heat to the oil shale to pyrolyze (break down with high temperature) the kerogen. Chemical treatment processes also may be applied. Aboveground retorting (AGR) technologies are used to process mined oil shale; the retorting processes are typically preceded by a variety of pretreatment activities, including crushing, sizing, and sorting. A number of AGR technologies have been designed in the past and are considered to be potentially applicable for future commercial oil shale development. These technologies include the Union B retort, The Oil Shale Corporation (TOSCO) II retort, Paraho retort (both direct and indirect modes), Lurgi-Ruhrgas process, Superior Oil's circular grate retort, and the Alberta Taciuk Process (ATP) technology. These technologies are discussed in Appendix A. The indirect recovery methods mentioned above involve in situ processing to separate the organic and inorganic constituents of the oil shale. These processes typically involve the application of high temperatures to achieve pyrolysis of the kerogen and allow its in situ recovery. Information from the BLM's ongoing oil shale RD&D projects that involve in situ processes is one possible source for defining the potential in situ technologies that may be used in the future.

Irrespective of the resource recovery and retorting technologies employed, kerogen pyrolysis products are likely to require further processing or upgrading before becoming attractive to oil refineries as feedstocks for conventional fuels. Upgrading crude shale oil at commercial project sites could consist of any or all of the following steps: separation of extraneous materials from the feedstock (e.g., water, suspended solids); separation of the crude oil fractions according to boiling points in atmospheric and/or vacuum distillations; coking or cracking to thermally decompose large molecules into smaller molecules; chemical treatment (e.g., catalytic or thermal hydrocracking, hydrotreating, desulfurization, or hydrogenation); and removal of other contaminants. These processes are discussed in Appendix A.

This PEIS evaluates the potential impacts of commercial oil shale technologies in three primary categories:

- Surface mining projects with surface retort facilities;
- Underground mining projects with surface retort facilities; and
- In situ processing projects.

While many hypothetical development scenarios could be constructed for each of these three technology categories, it is not possible to project or analyze all of them in this PEIS. Instead, the PEIS considers the components of current technologies that could be implemented in

order to analyze the range of potential impacts that could occur. It is likely that operators would consolidate a number of systems, such as power generation facilities, equipment maintenance, product storage and load-out facilities, steam and hot water production, water and wastewater treatment and recycling, and waste management, to achieve greater efficiencies and economies at a given project location.

In this PEIS, the BLM has limited its evaluation of the impacts of surface mining to those areas within the most geologically prospective oil shale areas where the overburden ranges in thickness from 0 to 500 ft. This limitation was based, in large part, on the assumption that 500 ft is about the maximum amount of overburden in which surface mining can occur economically, using today's technologies. As shown in Figure 2.3-1, the areas within the most geologically prospective oil shale areas where the overburden is 0 to 500 ft thick are limited to part of the Uinta Basin in Utah and parts of the Green River and Washakie Basins in Wyoming. In Utah, about 133,194 acres of land within the most geologically prospective oil shale area have an overburden thickness of 0 to 500 ft; all of these lands fall within the Vernal RMP planning area. In Wyoming, the corresponding area includes about 380,220 acres within the Green River RMP planning area. Within the most geologically prospective oil shale area defined in the Piceance Basin in Colorado, the most geologically prospective areas where the overburden is 0 to 500 ft thick are very limited, and it would be difficult to assemble a logical mining unit.[4] In Alternatives 1, 2 and 4, the PEIS considers making land available for lease for surface mining only in Utah and Wyoming, in those areas shown in Figure 2.3-1.

This PEIS is being developed to analyze the proposed action to amend 10 existing land use plans to designate certain public lands as available or not available for future oil shale and tar sands leasing. It includes descriptions and analyses not of particular levels of development, but of the possible impacts of each of the three primary categories of technology currently under consideration and research, so far as this information is available to the BLM at this time. Analysis of this information will allow the BLM to determine how best to allocate certain public lands where the resources are known to be located as available or not available for application to lease in the future.

If and when the BLM receives applications to lease oil shale as well as the additional information to make such a decision, the BLM will conduct additional NEPA and other required analyses, including consideration of direct, indirect, and cumulative effects, reasonable alternatives, and possible mitigation measures appropriate to the anticipated development. On the basis of that NEPA analysis to be conducted at the lease stage, the BLM will consider further amendment of one or more plans, if necessary, including, but not limited to, the establishment of general lease stipulations and BMPs.

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[4] The areas within the most geologically prospective oil shale areas where the overburden is 0 to 500 ft thick were mapped on the basis of a variety of sources of information. In Colorado, the area was defined on the basis of data published in Donnell (1987). In Utah, the area was mapped on the basis of data provided by the Utah Geological Survey (Tabet 2007). In Wyoming, the area was mapped on the basis of data provided by Wiig (2006a,b).

2.3.2 Alternative 1, Oil Shale No Action Alternative, No Change to 2008 Decision

Under Alternative 1, the No Action Alternative, no existing land use plans would be amended. In 2008, the BLM designated a total of 2,017,714 acres[5,6] available for application for commercial oil shale leasing and 430,686[6] acres available for commercial tar sands leasing (Figures 2.3.2-1, 2.3.2-2, and 2.3.2-3 for Colorado, Utah, and Wyoming, respectively). Table 2.3.2-1 lists the approximate number of acres of BLM-administered lands available for application for commercial oil shale leasing under Alternative 1 by state.[7]

The lands available for lease under the 2008 land use plan amendment decisions would remain available for future leasing consideration under the No-Action Alternative. These public lands comprise the most geologically prospective oil shale and tar sands areas administered by the BLM, including split estate lands where the federal government owns the mineral rights, but excluding lands that are exempted by statute, regulation, or E.O., as described in Section 2.3.3. Other exempted lands include: the mechanically-minable trona area in Wyoming; lands within incorporated towns and within city limits; historic trails; the Monument Valley Management Area; Management Area 3—the Jack Morrow Hills Planning Area in Wyoming; and expansion areas around Rock Springs and Green River, Wyoming. Split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation would potentially be available for leasing. These lands total approximately 57,657 acres.

Under the 2008 OSTS ROD (BLM 2008b), which forms the basis for the No Action Alternative, ACECs are treated in the following manner. Those ACECs that were closed for mineral development would be closed to oil shale/tar sands leasing; those ACECs open for mineral development would be open to oil shale/tar sands leasing. With respect to LWC, no specific decision was made in the 2008 ROD. Rather, as noted in the 2008 OSTS PEIS, the decision as to how to manage these areas was left to the discretion of the individual BLM field offices, which would determine the management of such areas through additional planning and NEPA processes (2008 Final OSTS PEIS, pp. 4-21, 4-22). Similarly, with respect to the management of sage-grouse habitat, the 2008 ROD made no specific decisions; rather, the 2008 Final OSTS PEIS included a text box discussing BLM's policies and general practices, including specific frequently used mitigation measures that might be applied to any development, as warranted by analysis at the lease and/or development stage (2008 Final OSTS PEIS, pp. 4-78 to 4-80). More recently, the BLM has issued nationwide and state-specific guidance recommending the consideration of certain management practices to address the appropriate management of sage-grouse habitat in the context of land use actions, and this information is presented in a text box in Section 4.8.1 of this PEIS. Under this No Action Alternative, as well as all of the other alternatives presented for analysis, field offices would need to take this guidance into account and incorporate protective measures in any authorizations, as warranted by

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5 This amount includes the total potential RD&D lease acreage of 30,720 acres.

6 In the 2008 OSTS PEIS, the corresponding acreages were estimated as 1,991,222 acres for oil shale and 431,224 acres for tar sands. These estimates are slightly revised here after recalibrating the geospatial data on which they are based for the current analysis.

7 The maps and acreage estimates were constructed by applying the leasing restrictions discussed in the text to the best available geographic information system (GIS) datasets available to the BLM.

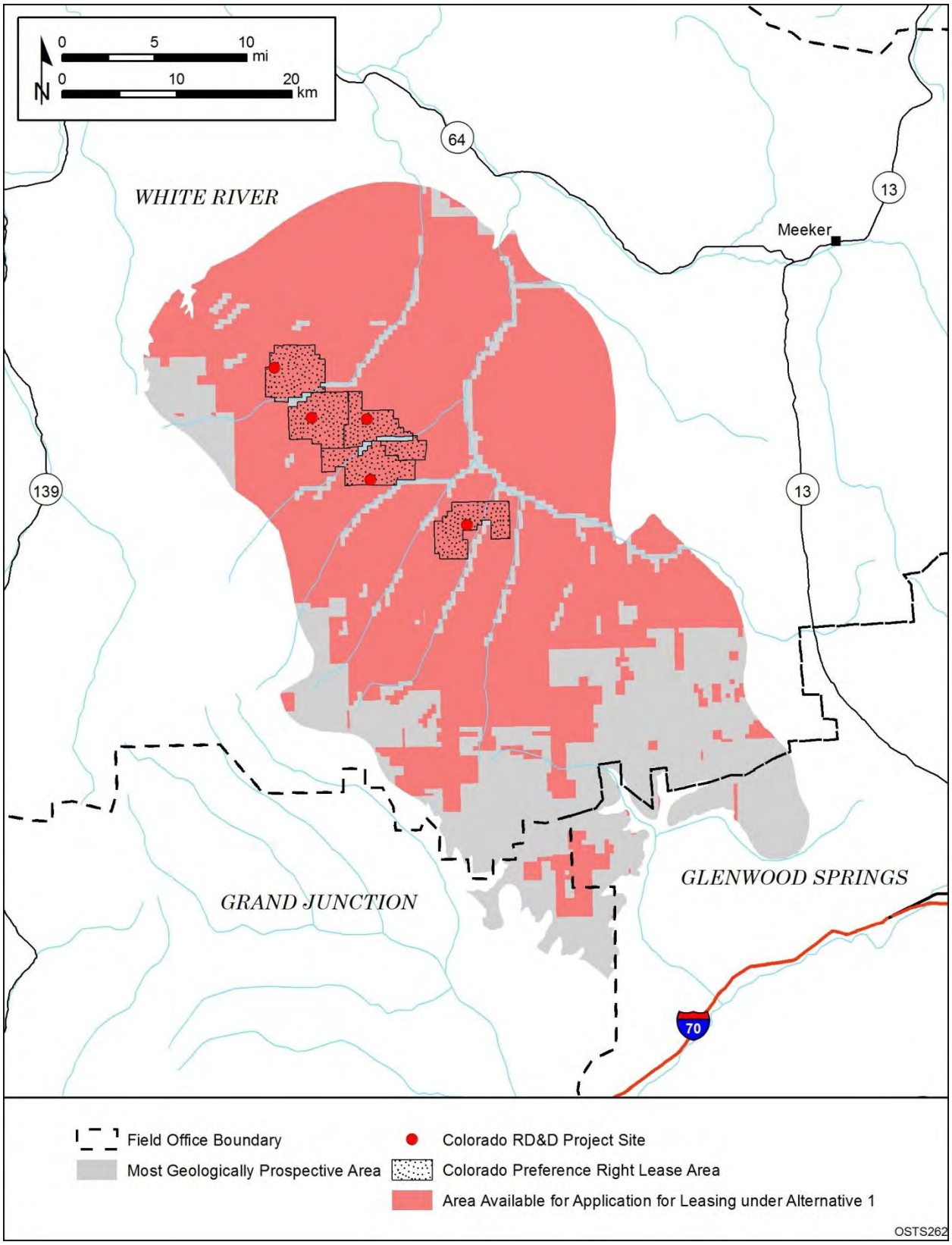

FIGURE 2.3.2-1 Lands Available for Application for Leasing under Alternative 1 in Colorado

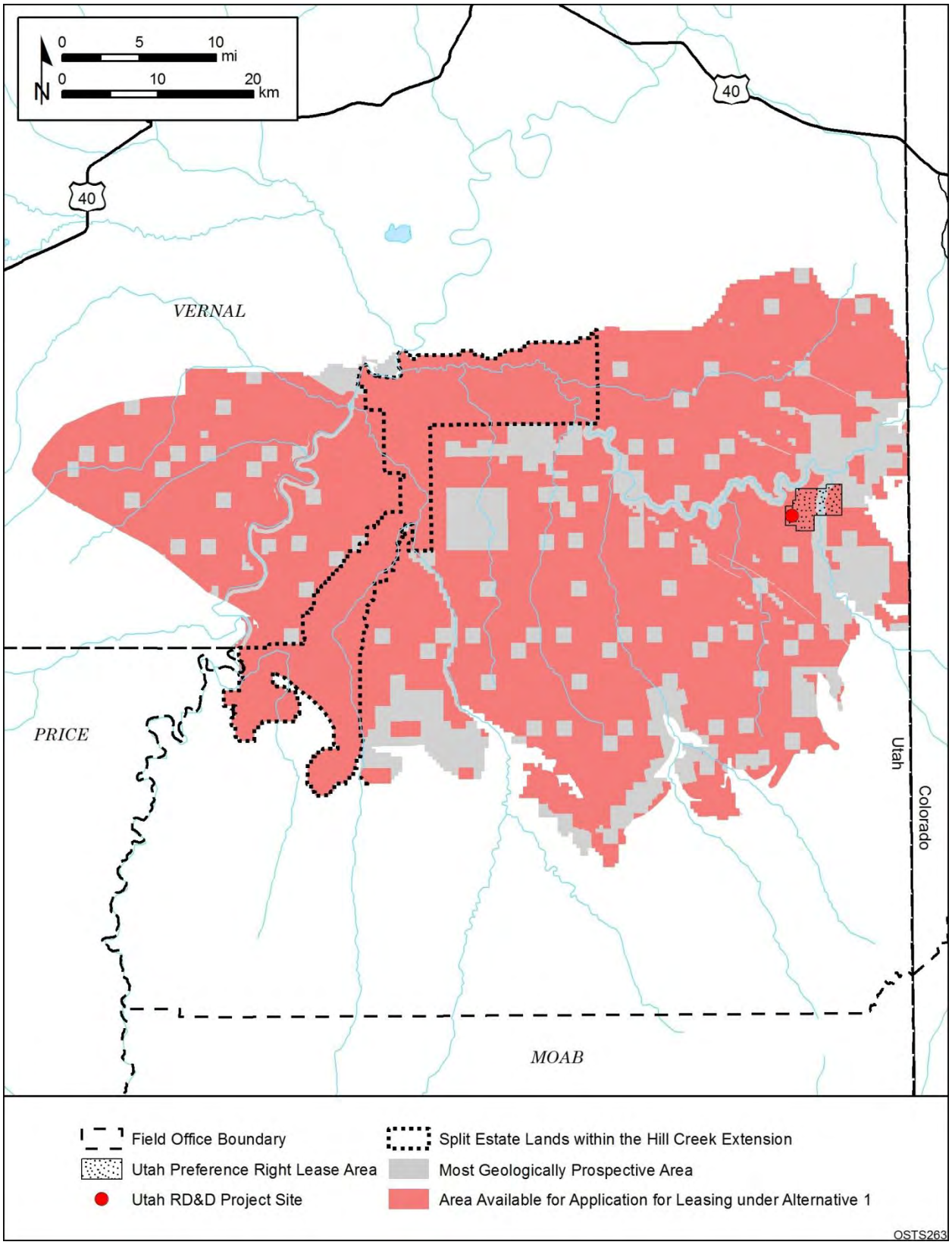

FIGURE 2.3.2-2 Lands Available for Application for Leasing under Alternative 1 in Utah

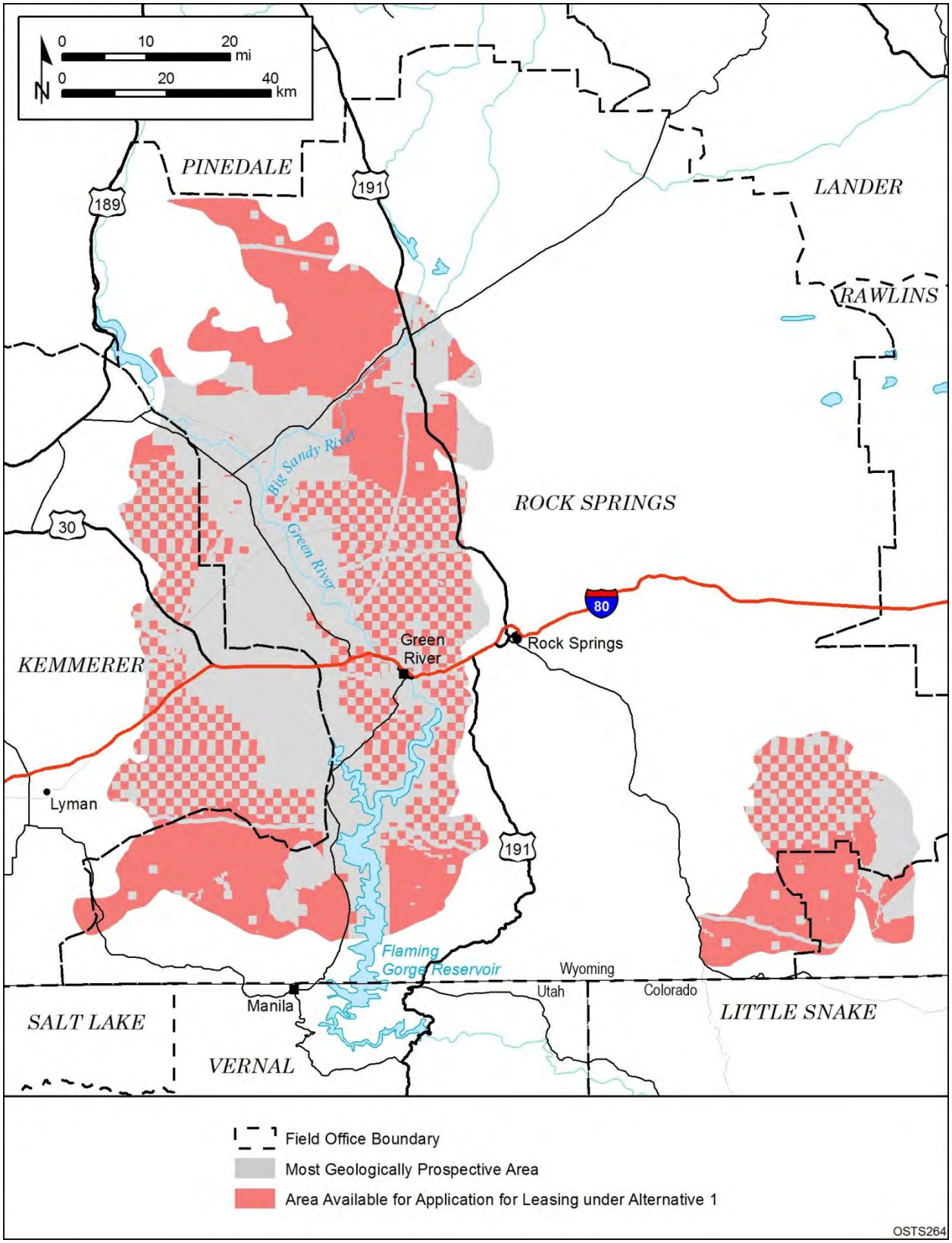

FIGURE 2.3.2-3 Lands Available for Application for Leasing under Alternative 1 in Wyoming

TABLE 2.3.2-1 Estimated Acres Potentially Available in Each State for Application for Leasing for Commercial Oil Shale Development under Alternative 1[a]

State	BLM-Administered Lands	Split Estate Lands	Total
Colorado[b]	307,136	39,473	346,609
Utah[c]	594,958	75,600	670,558
Wyoming	992,824	7,750	1,000,574
Total for Alternative 1	1,894,918	122,823	2,017,741

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS.

[b] Alternative 1 acreage is reduced by 13,308 acres compared to that in the 2008 OSTS PEIS due to removal of lands in NOSR 1 and NOSR 3 in Colorado. See Section 2.3.3 for further explanation.

[c] The split estate lands in Utah include 57,657 acres of split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation on which the surface rights are owned by the Ute Indian Tribe.

ecological conditions, and on the basis of environmental analysis. As such, it is likely that not all the areas that are currently open under this alternative for potential future leasing would be leased and/or developed. See the discussion under Alternative 4 for examples of what this might look like under different protective scenarios.

As shown in Figure 2.3.2-2, split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation are included in the lands proposed to be available for leasing under Alternative 1. These lands total 57,657 acres.

Also, as discussed in Section 2.3.1, commercial leases for surface mining projects would be allowed only on those lands in Utah and Wyoming where the overburden is 0 to 500 ft thick. In Utah, under Alternative 1, lands available for application for leasing for surface mining projects total about 85,640 acres in the Vernal RMP planning area. In Wyoming, under Alternative 1, these lands total about 248,000 acres in the Green River RMP planning area.

In Alternative 1, the PRLAs for the five RD&D projects in Colorado coincide entirely with the area proposed to be available for application for commercial leasing. Under the terms of the existing RD&D leases, the federal government has a commitment to grant the RD&D lessees leases for commercial development within the PRLAs, provided that all terms and conditions of the leases are met (see Section 1.4.1). As a result, all lands within the PRLAs would be available for issuance of commercial leases to the current RD&D lessees, subject to lease requirements.

The federal government is not under an obligation to grant leases for commercial development within the existing RD&D lease areas to any other applicants; however, under this alternative, if an existing RD&D leaseholder relinquishes its lease, the area would be available for consideration for future leasing.

The six RD&D leases that have been issued contain terms that allow development of the original leases and could allow development of the associated PRLAs, totaling 30,720 acres. A summary of the key lease terms regarding the PRLAs is provided in Section 1.4.1. For purposes of analysis and comparison, under Alternative 1, it is assumed that each of the leases could reach commercial production utilizing the technologies being tested on the leases and may utilize the whole PRLA leased area. Where the RD&D leases overlay lands classified for open pit (surface), underground, or multimineral development, it is assumed that only the technologies being tested on the individual leases will be utilized in the development. Under this alternative, if an individual RD&D lease holder relinquishes its lease, the area may be leased to another operator consistent with the decisions in the RMP existing at the time of application.

Table 2.3.2-2 provides a summary of the activities and constraints assumed to occur under Alternative 1.

2.3.3 Commercial Oil Shale Program Land Allocation Alternatives

This PEIS analyzes three programmatic land allocation action alternatives in addition to the No Action Alternative. Under each new allocation alternative, 10 land use plans would be amended to (1) identify the most geologically prospective oil shale resources within each planning unit, (2) designate lands within these most geologically prospective areas as available or not available for application for commercial oil shale and tar sands leasing, and (3) identify any technology restrictions. As noted in Chapter 1, the following decisions from the 2008 OSTS PEIS ROD will be carried forward through this planning process and would be applicable regardless of the alternative eventually selected for adoption: the requirement for future NEPA, ESA, and other applicable analyses and consultation activities to occur prior to any decision to lease and/or develop oil shale and tar sands resources; and the specific decision that the BLM will consider and give priority to the use of land exchanges to facilitate commercial oil shale development pursuant to Section 369(n) of the Energy Policy Act of 2005. Table 2.3.2-2 compares the three alternatives. The plans that would be amended under these alternatives include the following:

- Colorado
  - Glenwood Springs RMP (BLM 1988, as amended by the 2006 Roan Plateau Plan Amendment [BLM 2006b, 2007a, 2008c])
  - Grand Junction RMP (BLM 1987)
  - White River RMP (BLM 1997b, as amended by the 2006 Roan Plateau Plan Amendment [BLM 2006b, 2007a, 2008c])

- Utah
  - Monticello RMP (BLM 2008d)
  - Price RMP (BLM 2008e)

TABLE 2.3.2-2 Summary of Activities and Conditions Assumed for Each of the Oil Shale Alternatives

Condition	Alternative 1 (No Action)	Alternative 2 (Conservation Focus)	Alternative 3 (Research Lands Focus)	Alternative 4 (Moderate Development)
Land use plans amended	No land use plans in Colorado, Utah, and Wyoming will be amended.	10 land use plans in Colorado, Utah, and Wyoming will be amended.	Same as Alternative 2	Same as Alternative 2.
Potential area available for application for leasing (RD&D and commercial leases)	2,017,741 acres would be made available for application for commercial lease: Colorado, 346,609 acres Utah, 670,558 acres Wyoming, 1,000,575 acres Under this alternative, the 30,720 acres included in the existing RD&D leases will be available for future leasing if the current leaseholders relinquish their existing leases.	461,965 acres would be made available for application for commercial lease: Colorado, 35,308 acres Utah, 252,181 acres Wyoming, 174,476 acres Under this alternative, of the 30,720 acres included in the existing RD&D leases, if current leaseholders relinquish their leases, only 6,612 acres within the current RD&D lease areas would be available for future leasing.	32,640 acres would be available for application for commercial lease for five current RD&D leases in Colorado and one current RD&D lease in Utah and two potential new leases in Colorado and one in Utah.	1,472,370 to 1,963,414[a] acres would be made available for application for commercial lease: Colorado, 321,071 to 340,147[a] acres Utah, 458,421 to 655,821[a] acres Wyoming, 692,878 to 967,446[a] acres Under this alternative, the 30,720 acres included in the existing RD&D leases will be available for future leasing if the current leaseholders relinquish their existing leases.
Technologies considered	In situ processes. Underground mining with surface retort. Surface mining with surface retort (only in Utah and Wyoming in areas where the overburden is 0 to 500 ft thick).	Same as Alternative 1.	Same as Alternative 1,	Same as Alternative 1.

TABLE 2.3.2-2 (Cont.)

Condition	Alternative 1 (No Action)	Alternative 2 (Conservation Focus)	Alternative 3 (Research Lands Focus)	Alternative 4 (Moderate Development)
Lands excluded from commercial leasing	• Wilderness Areas, WSAs, and other areas that are part of the NLCS. • ACECs existing as of the signing of the 2008 OSTS ROD that are currently closed to mineral development. • The MMTA in Wyoming. • Segments of rivers determined to be eligible for WSR status by virtue of a WSR inventory. • Historic trails. • Monument Valley Management Area in Wyoming. • Management Area 3, Jack Morrow Hills Planning Area in Wyoming. • Incorporated town and city limits. • NOSRs 1 and 3 in Colorado	Same as Alternative 1 plus: • All areas that the BLM has identified or may identify as a result of inventories conducted during this planning process, as lands containing wilderness characteristics • The whole of Adobe Town "Very Rare or Uncommon Area." • Core or priority sage-grouse habitat, as defined by such guidance that the BLM or DOI might issue. • All ACECs analyzed in the 2008 OSTS PEIS plus additional ACEC acreages as a result of Colorado, Utah and Wyoming planning efforts recently completed, as well as areas under consideration for designation as ACECs under current planning processes. • All areas identified as excluded in Alternative C of the 2008 OSTS PEIS (see Section 2.3.3.1).	All lands will be excluded from application for lease except lands within six current and three potential new RD&D leases.	Same as alternative 1 plus: • The whole of Adobe Town "Very Rare or Uncommon Area." • All ACECs analyzed in the 2008 OSTS PEIS plus additional ACEC acreages as a result of Colorado, Utah, and Wyoming planning efforts recently completed, as well as areas under consideration for designation as ACECs under current planning processes.

TABLE 2.3.2-2 (Cont.)

Condition	Alternative 1 (No Action)	Alternative 2 (Conservation Focus)	Alternative 3 (Research Lands Focus)	Alternative 4 (Moderate Development)
Regulatory and operational constraints	All commercial development would be conducted in compliance with existing federal, state, and local regulatory requirements and established BLM policies.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Additional NEPA requirements	Additional NEPA analysis would be required before any leases for commercial development can be issued. Site-specific NEPA analysis also would be conducted during review and approval of project plans of development.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

Abbreviations: ACEC = Area of Critical Environmental Concern; BLM = Bureau of Land Management; DOI = U.S. Department of the Interior; MMTA = Mechanically Mineable Trona Area; NLCS = National Landscape Conservation System; NEPA = National Environmental Policy Act; NOSR = Naval Oil Shale Reserves; OSTS = oil shale and tar sands; RD&D = research, development, and demonstration; WSA = Wilderness Study Area.

[a] This range corresponds to 75% protection of LWC and sage-grouse core and priority habitat at the low end to no protection at the high end.

  - Richfield RMP (BLM 2008f)
  - Vernal RMP (BLM 2008g)

- Wyoming
  - Green River RMP (BLM 1997a, as amended by the Jack Morrow Hills Coordinated Activity Plan [BLM 2006a])
  - Kemmerer RMP (BLM 2010)
  - Rawlins RMP (BLM 2008e)

The potential impacts from oil shale development and the possible mitigation measures discussed in the Chapter 4 impact analyses could be considered, as appropriate, during the future lease and project-specific NEPA analyses that would be required prior to leasing and/or development under all of the alternatives.

In all three allocation action alternatives, the BLM recognized that the six existing RD&D leases contain terms and conditions that could allow commercial development of the original leases and the associated PRLAs totaling 30,720 acres. A summary of the key lease terms and conditions regarding the PRLAs is provided in Section 1.4.1. For purposes of analysis and comparison, under all three allocation alternatives, it is assumed that each of the leases could reach commercial production utilizing the technologies being tested on the leases, and utilizing up to the entire leased area. If an initial RD&D lease holder relinquishes its lease, different acreages within the existing RD&D and PRLA lease areas would be available for future leasing under each alternative as noted in Table 2.3.2-2 above and as described in the discussion below.

Also, in all three allocation alternatives, new RD&D leases could be issued in any areas opened to commercial oil shale leasing. New RD&D projects might precede commercial oil shale leasing or might be conducted contemporaneously with commercial leasing and operations. Impacts from new RD&D projects are anticipated to be qualitatively similar but smaller in scale than those of commercial projects, at least until any RD&D lease might be converted to a commercial oil shale lease and expanded to include preference right acreage. Additional NEPA analysis would be required prior to issuance of any RD&D lease and prior to conversion of an RD&D lease to a commercial oil shale lease and expansion into a PRLA.

As discussed in Section 1.2, the BLM has determined that certain lands within the most geologically prospective oil shale resource areas must be excluded from commercial leasing, under all alternatives, to comply with existing laws and regulations, E.O.s, land use plan designations, and other administrative designations or withdrawals. As a result, commercial leasing is excluded from all designated Wilderness Areas, WSAs, and other areas that are part of the NLCS lands administered by the BLM (e.g., National Monuments, NCAs, WSRs, National Historic Landmarks, and National Historic and Scenic Trails), existing ACECs that are currently closed to mineral development, and lands within incorporated town and city limits. This includes the NOSR 1 and 3 lands that were erroneously included as open under the 2008 OSTS PEIS (BLM 2008a).

Oil shale deposits, generally, were originally withdrawn in 1930 (E.O. 5327, "Withdrawal of Public Oil-Shale Deposits, and Lands Containing Same for Investigation,

Examination, and Classification" [U.S. President 1930]) by President Herbert Hoover, subject to valid existing rights. The E.O. temporarily withdrew the deposits of oil shale and lands containing such deposits owned by the United States from lease or other disposal, in order to protect the oil shale resource, pending classification under the applicable public land laws. Oil shale was later determined to be leasable in 1954 (retroactive to 1920). A later withdrawal order issued in 1968 (Public Land Order 4522) added to the protection of oil shale on these same lands, permanently withdrawing them from appropriation under the mining law and from sodium leasing, unless it could be shown that sodium mining would not cause significant damage to oil shale beds.

Section 204 of FLPMA requires the BLM to review existing withdrawals to determine if they are still needed for their original purpose. Since oil shale and associated minerals (nahcolite, sodium, and dawsonite) have been determined to be leasable and current policy and procedures provide for adequate protection of the oil shale resource, the oil shale withdrawals are no longer needed to administer public lands. Therefore, as these oil shale withdrawal orders have, over time, been recognized as being no longer needed, they have been revoked in part, on several occasions, lifting the withdrawals from most public lands. The NOSRs 1 and 3 are an exception to this general trend. Congress transferred jurisdiction over these lands from DOE to the BLM in the 1997 Transfer Act. The NOSRs were originally set aside for national security purposes (this was after the turn of the century when the Navy turned from coal-fired to oil-fired vessels), and the statutes under which they were managed by DOE reflected this purpose. In the 1997 Transfer Act, in recognition that national defense needs no longer warranted such interest in oil shale (see P L. 105-85, codified as amended at 10 USC 7439), Congress expressed the need to dispose of the property in a way that benefitted the taxpayers, and provided for the transfer of NOSRs 1 and 3 to management by the BLM. However, the Transfer Act did not, itself, revoke the original withdrawal, and only specifies that the BLM should lease resources subject to the Act, "for the purpose of exploration for, and development and production of, petroleum (other than in the form of oil shale) located on or in public domain lands in Oil Shale Reserves numbered 1 and 3…" Nor has the Secretary of the Interior subsequently revoked the withdrawal pursuant to Section 204 of FLPMA. Therefore, the withdrawal is still in effect on NOSRs 1 and 3, and these lands are closed and not available for future opportunity to lease for the development of oil shale resources under all alternatives, including the No Action Alternative. The 2008 OSTS PEIS (BLM 2008a) did not include a NEPA analysis to open these lands for future oil shale leasing; rather, it did not specifically state that they were excluded from future oil shale leasing. In addition, the map of the preferred alternative in Colorado incorrectly showed them as open. The NOSRs 1 and 3 total 56,238 acres.

The BLM has also determined that additional areas would be closed and would not be available for future opportunity to lease for commercial development of oil shale resources under all allocation action alternatives. These additional areas include:

- *Mechanically Mineable Trona Area (MMTA)*. This area, which is located in the Green River Basin in Wyoming, falls within a portion of the Known Sodium Leasing Area (KSLA) that encompasses the world's largest known

trona deposits.[8] Trona leases have been issued within this area, and production occurs from a number of underground mines. The BLM has determined that the MMTA would 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.

- *Segments of rivers that the BLM has determined to be potentially eligible for WSR status by virtue of a WSR inventory*. These river segments and a corridor extending at least 0.25 mi from the high water mark on either side of these segments would be excluded from commercial leasing (see footnote 2 on p. 2-11 for a discussion of this restriction).

- *Historic trails*. Historic trails identified by the BLM Wyoming State Office and a corridor extending at least 0.25 mi on either side of the trail would be excluded from commercial leasing.[9]

- *Monument Valley Management Area.* Oil shale development within this management area, which is located in the Rock Springs Field Office area, is prohibited in the Green River RMP (BLM 1997a). Specifically, the RMP directs that these lands remain withdrawn from oil shale development until a comprehensive study of the area has been conducted, including an assessment of the potential designation of this area as an ACEC on the basis of the need to protect cultural and paleontological resources.

- *Management Area 3, Jack Morrow Hills Planning Area.* In accordance with the Jack Morrow Hills Coordinated Activity Plan (BLM 2006a), extensive restrictions on surface-disturbing activities have been established for Area 3 within the Jack Morrow Hills Planning Area because of the presence of sensitive natural and cultural resources. The portion of Area 3 that overlaps with the most geologically prospective oil shale resources in the Green River Basin is restricted to No Surface Occupancy (NSO) and has been excluded from future leasing on the basis of input from the field office.

- *Expansion Areas around Rock Springs and Green River, Wyoming.* The BLM has determined that it will not issue leases within the "expansion areas" agreed upon with the cities of Rock Springs and Green River, Wyoming.

- *Incorporated Town and City Limits.* The BLM has determined that it will not issue leases within incorporated town and city limits.

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

[9] For the purposes of analysis in this PEIS, the centerline of trails mapped in the GIS was used to define the 0.25 mi buffer.

Public lands outside of the most geologically prospective area are not being excluded from consideration for leasing for any environmental or other specific reason and could be considered for application for leasing at a later time but would require consideration in a new NEPA analysis and a land use plan amendment before leasing could be authorized. Areas within the most prospectively valuable area that are excluded from consideration for application for leasing in the current PEIS, or environmentally and economically sound proposals employing different technologies, could also be considered in the future.

Leasing would occur pursuant to regulations governing the leasing and development of oil shale (73 FR 69469) (Nov. 18, 2008); codified at 43 CFR Parts 3900–3930). While the BLM is in the process of considering amendments to this rule, this PEIS does not depend on any particular provision of the rule but anticipates that decisions regarding leasing and approval of plans of development will be informed by appropriate analysis documents as required by NEPA and other applicable authorities.

In general, however, under the oil shale regulations, the process for authorizing oil shale leasing and development would proceed as follows. The BLM would issue a call for applications for commercial leases that may be restricted to certain areas. In response, companies would be required to identify the specific lands that they are interested in as part of their lease application package. It is also possible that the BLM would identify specific tracts to be leased in the call for applications. The proposed process would require that NEPA analyses be conducted prior to lease issuance. Information collected as part of the lease application process would be incorporated into the NEPA analysis. Applicants would be required to identify key information regarding aspects of the proposed development needed to support a complete NEPA review (e.g., technologies to be employed, level of planned development, anticipated off-site impacts, and strategies to comply with regulatory requirements). During that NEPA review, the BLM would identify and establish appropriate lease stipulations to mitigate anticipated impacts. In addition, the subsequent approval of project-specific plans of development would require NEPA review to (1) consider site-specific and project-specific factors and (2) identify and require appropriate mitigation measures as needed to control impacts beyond those established in the lease stipulations. The NEPA review for the plan of development may be incorporated into the NEPA review conducted for the lease application, at BLM's discretion, and if adequate operational data are provided by the applicant(s). Under Alternatives 2b and 4b, where RD&D leasing will be required prior to a lessee obtaining a commercial lease, the BLM is still in the process of working out the exact details of the process, but expects at this point that the RD&D leasing process will be detailed in the *Federal Register* Notice announcing the Request for Nomination.

Under all allocation action alternatives, the BLM would require that the operator conduct commercial development in compliance with existing federal, state, and local regulatory requirements and established BLM policies, as generally described in Section 2.2 and Appendix D. This compliance would include, as appropriate, obtaining and complying with all required permits (e.g., air, water, and waste management) as required by regulatory agencies; and operating within the permit constraints. In addition, the operator would have to conduct any commercial development consistent with any constraints that emerged from the BLM's completion of consultation, as appropriate, with the USFWS under Section 7 of the ESA in

connection with authorization of any leasing/development project(s), and its completion of consultation with State Historic Preservation Officers (SHPOs), Tribal Historic Preservation Officers, and other consulting parties under Section 106 of the NHPA (P.L. 89-665) in connection with authorization of any leasing/development project(s). The operator would have to conduct any commercial development in compliance with any other relevant and applicable requirements, as well. Compliance-related conditions would be developed on a project-by-project basis during site-specific analyses.

Under all allocation action oil shale alternatives, in Colorado, lands within the Multimineral Zone identified in the White River RMP (BLM 1997b) would be made available for application for commercial lease only if the applicant can demonstrate that it would use technologies that allow recovery of oil shale resources without preventing the recovery of or otherwise destroying other minerals (i.e., nahcolite and dawsonite).

2.3.3.1 Alternative 2, Oil Shale Conservation Focus (Alternative 2a), with RD&D First Requirement (2b)

Under this alternative, 10 land use plans in Colorado, Utah, and Wyoming would be amended to designate less than 830,000 acres (acreage opened under Alternative C in the 2008 OSTS PEIS) available for future commercial oil shale leasing.[10] This alternative would exclude from commercial oil shale leasing the following categories or groups of categories of public lands and/or their resource values that may warrant protection from potential oil shale leasing and development:

1. All areas that the BLM has identified or may identify as a result of inventories conducted during this planning process, as LWC;

2. The whole of the Adobe Town "Very Rare or Uncommon" area, as designated by the Wyoming Environment Quality Council on April 10, 2008 (180,910 acres total; 167,517 acres of public land, of which 10,920 acres are already a BLM WSA);

3. Core or priority sage-grouse habitat, as defined by such guidance as the BLM or the DOI may issue;

4. All ACECs located within the areas analyzed in the 2008 OSTS PEIS (76,666 acres in existing ACECs in the 2008 OSTS PEIS plus additional

[10] In a February 15, 2011, settlement of a lawsuit brought by several environmental advocacy groups challenging the 2008 OSTS PEIS and ROD, the DOI and BLM agreed to analyze an alternative that considers excluding from oil shale/tar sands leasing and development all lands containing the resource types listed, as well as an alternative that considers excluding from oil shale/tar sands leasing and development some portion of the lands containing the resource types listed. The latter alternative is represented by Alternative 4, the Moderate Development Alternative, described below.

ACEC acreages as a result of Utah and Wyoming planning efforts recently completed)[11]; and

5. All areas identified as excluded from commercial oil shale and tar sands leasing in Alternative C of the September 2008 OSTS PEIS (Alternative C made 830,296 acres available for potential commercial oil shale leasing and 229,038 acres available for potential commercial tar sands leasing).

RD&D First Requirement (2b). Under this alternative, the lands open for future leasing consideration would be the same as those in Alternative 2(a), but only for RD&D leases. The BLM would issue a commercial lease only when a lessee satisfies the conditions of its RD&D lease and the regulations at 43 CFR. Subpart 3926 for conversion to a commercial lease. The preference right acreage, if any, which would be included in the converted lease, would be specified in the RD&D lease.

The environmental impacts of Alternative 2(b) would be analytically indistinguishable from those of Alternative 2(a). Only the method of obtaining a lease would be different. Accordingly, the analysis in this PEIS of Alternative 2 applies fully and equally to both alternatives. To the extent there may be differences in environmental consequences between Alternative 2(a) and 2(b), these would be related to the timing of the commencement of impacts, as well as, possibly, length of disturbance. However, these issues are best addressed in the lease and/or project-specific analysis.

The benefits of Alternative 2(b) would include facilitating a robust RD&D program. It would also avoid allowing a few companies to tie up large areas with speculative commercial leases. Thus it would promote access by innovative small companies to the federal oil shale resource for RD&D.

In the event that a commercially viable technology is demonstrated and becomes widely available in the near future, it is possible that Alternative 2(b) could result in delaying commercial leasing on federal lands. If that possibility, however speculative at the present, were to occur, the pertinent RMPs could be amended contemporaneously with review of proposed commercial leases. The oil shale leasing and management regulations at 43 CFR Part 3900 would not be affected by the selection of any alternative analyzed in this PEIS, and thus would remain available for future decisions concerning commercial leasing.

As the Draft PEIS was being developed, the idea for this alternative emerged. It is presented here in brief. This alternative is not noted elsewhere in the document but will be developed further in preparation of the Final PEIS. Analytically, this subalternative is indistinguishable from Alternative 2(a) in terms of environmental consequences. Therefore further environmental analysis in preparation of the Final PEIS is not anticipated, although more detailed explanation may be provided, particularly in response to comments received.

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[11] This would include analysis of excluding from future oil shale and tar sands leasing not only all ACECs, but also areas that had been under consideration for designation as ACECs in the applicable plans undergoing revision or amendment at the time, but which were eventually not designated.

Lands that fall under items 1 through 4, above, in and around the most geologically prospective oil shale areas in Colorado, Utah, and Wyoming are shown in Figures 2.3.3-1, 2.3.3-2, and 2.3.3-3, respectively. The Adobe Town "Very Rare or Uncommon" area is shown in Figure 2.3.3-3 in the eastern portion of the Washakie Basin in Wyoming. These various areas excluded from lands available for application under Alternative 2 are lands that were considered for exclusion under Alternative C of the 2008 OSTS PEIS, as noted in item 5 above.

Lands available for application for oil shale leasing within the most geologically prospective area under Alternative 2 in Colorado, Utah, and Wyoming are shown in Figures 2.3.3-4, 2.3.3-5, and 2.3.3-6, respectively. Table 2.3.3-1 lists by state the approximate number of acres of BLM-administered land available for application for leasing under Alternative 2. Table 2.3.3-2 identifies the types of stipulations and restrictions in place for oil and gas leasing in each state that were used to identify those lands that would not be available for application for leasing for commercial oil shale development under Alternative C of the 2008 OSTS PEIS. These lands total 57,657 acres.

In Alternative 2, portions of three of the five PRLAs for the Colorado RD&D leases are not identified as available for application for commercial leasing. These include portions of the areas associated with the Chevron, AMSO, and Shell Site 2 RD&D projects. For the other two Colorado RD&D projects, Shell Sites 1 and 3, none of the PRLAs coincide with the area identified as available for application for commercial leasing.

Also, as discussed in Section 2.3.1, commercial leases for surface mining projects would be allowed only on those lands in Utah and Wyoming where the overburden is 0 to 500 ft thick. In Utah, under Alternative 2, lands available for application for leasing for surface mining projects total about 85,640 acres in the Vernal RMP planning area. In Wyoming, under Alternative 2, these lands total about 248,000 acres in the Green River RMP planning area.

2.3.3.2 Alternative 3, Oil Shale Research Lands Focus (RD&D with PRLA only)

Several comments were received during the public scoping process that suggested that the BLM should not move forward to establish commercial leasing programs for oil shale or tar sands development on public lands. The variety of concerns cited as reasons for not establishing commercial programs included (1) the sensitivity of specific resources within the three-state study area, such as LWC, visual resources, ecological resources, and cultural resources; (2) the lack of definitive information about the technologies that will be employed in commercial operations; (3) the need for the nation to focus on alternative sources of energy, such as renewable resources; and (4) in the case of oil shale, the potential recurrence of adverse socioeconomic impacts resulting from a possible boom or bust cycle of development. Under this Research Lands Focus Alternative, developed in consideration of these comments, 10 land use plans would be amended such that public lands for commercial leasing would be available only where there were existing RD&D leases at the time the ROD for the 2012 Final OSTS PEIS is signed. The six current RD&D leases contain terms and conditions that could allow commercial development of the original leases and the associated PRLA totaling 30,720 acres. Another three potential RD&D leases (two in Colorado and one in Utah) are currently undergoing NEPA analysis. Maximum acreage of these three leases, if approved, would be 1,920 acres, bringing the total acreage to 32,640 acres as available for potential oil shale leasing under this alternative.

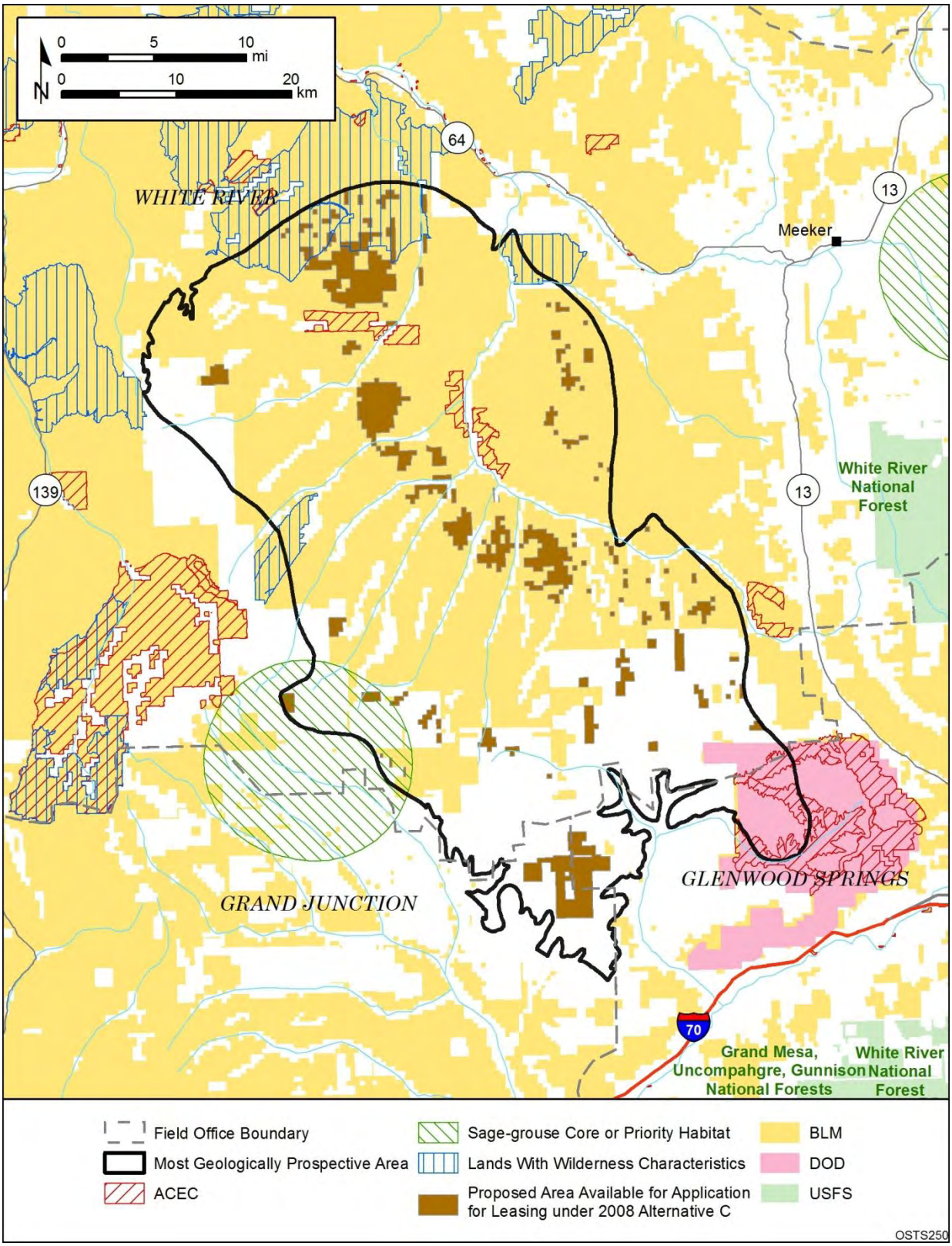

FIGURE 2.3.3-1 Lands Excluded from Application for Oil Shale Leasing under Alternative 2 in Colorado

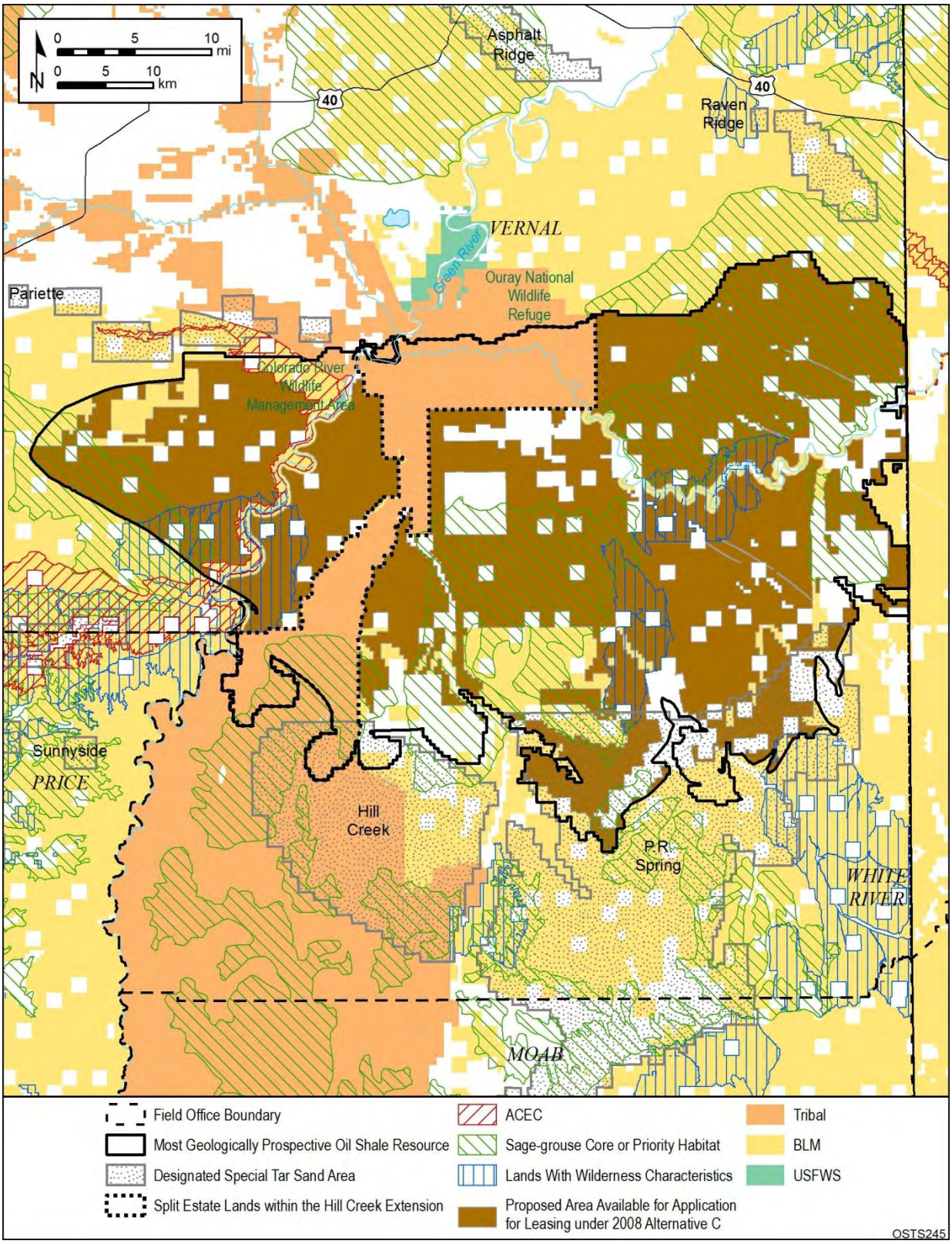

FIGURE 2.3.3-2 Lands Excluded from Application for Oil Shale Leasing under Alternative 2 in Utah

FIGURE 2.3.3-3 Lands Excluded from Application for Oil Shale Leasing under Alternative 2 in Wyoming

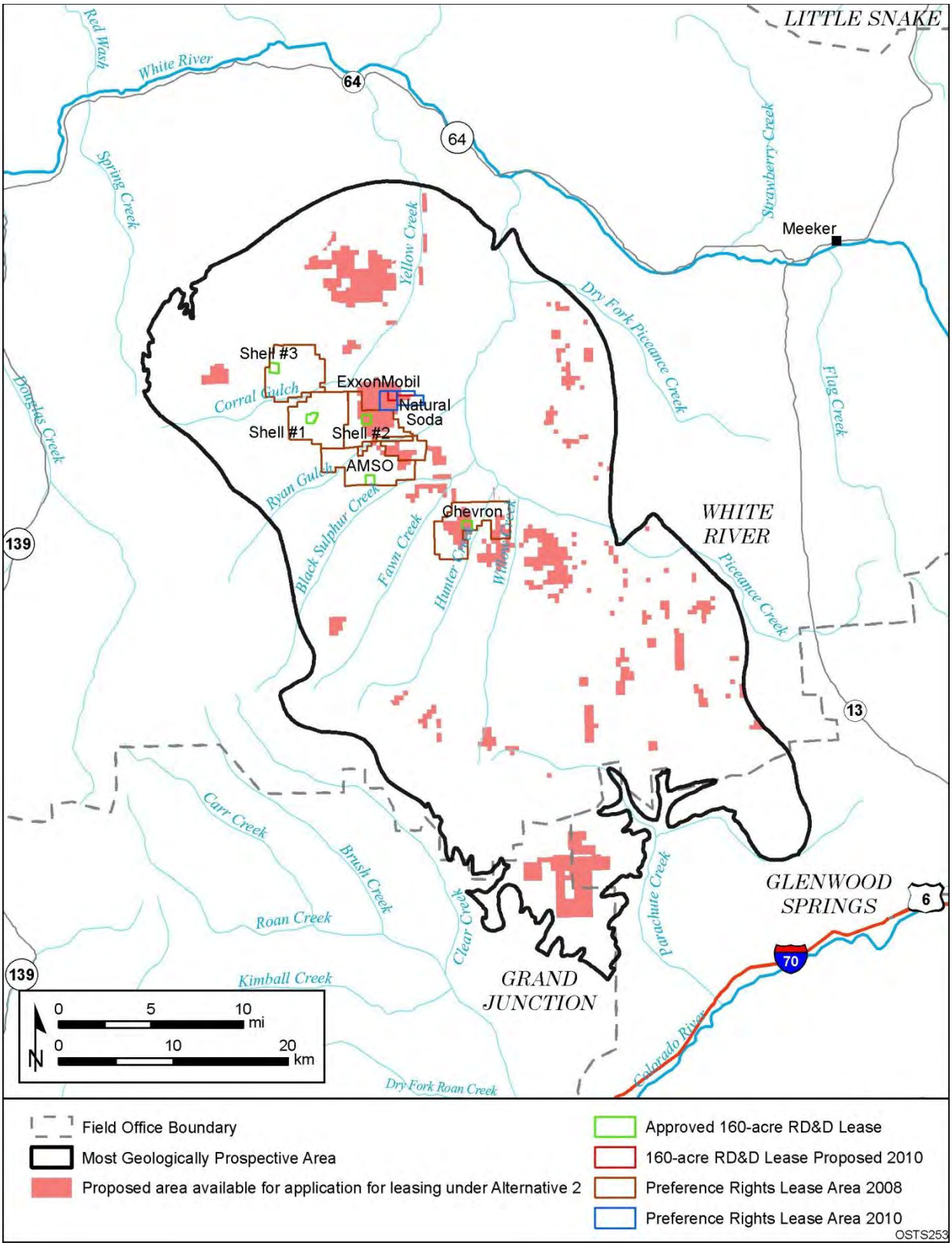

FIGURE 2.3.3-4 Lands Available for Application for Oil Shale Leasing under Alternative 2 in Colorado

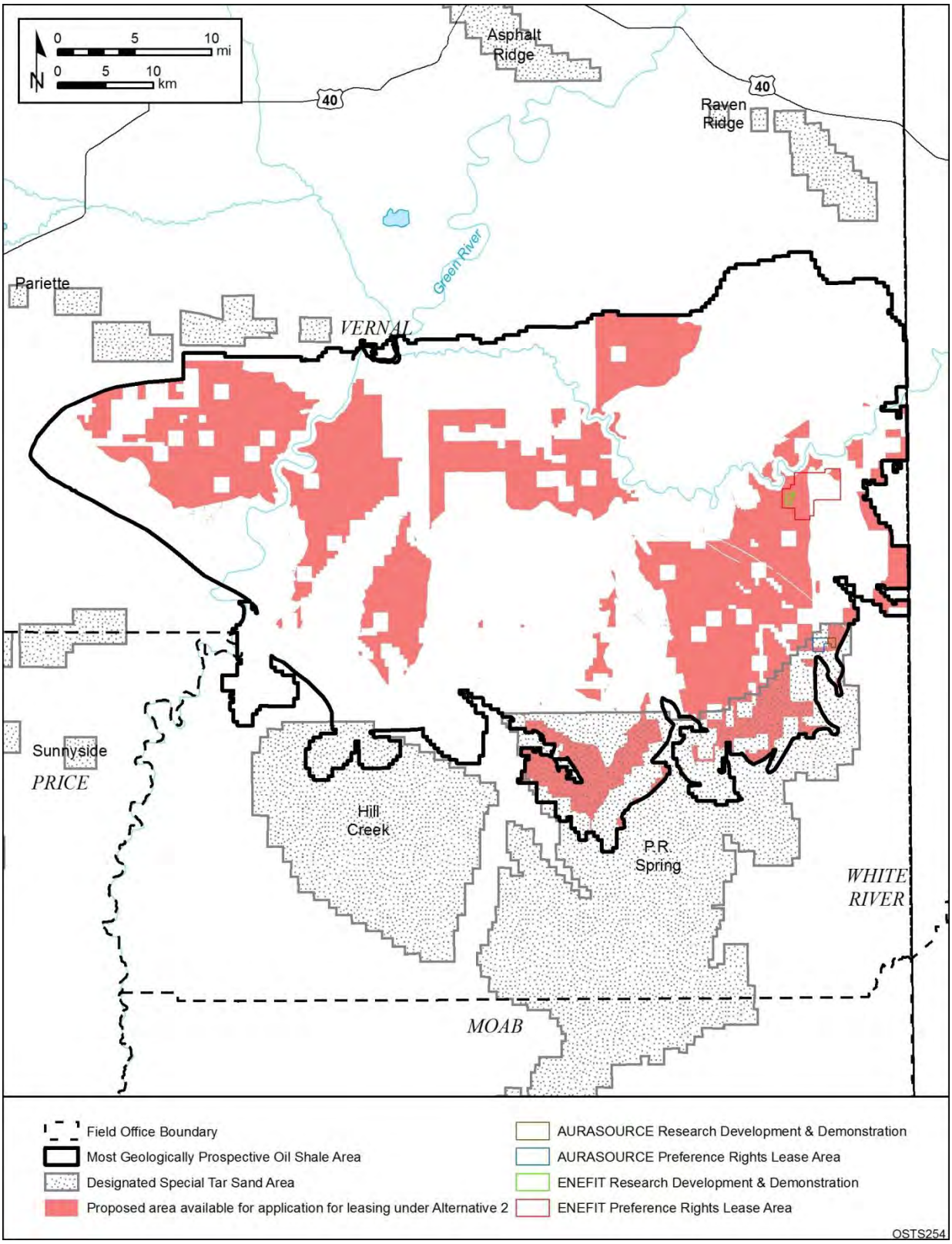

FIGURE 2.3.3-5 Lands Available for Application for Oil Shale Leasing under Alternative 2 in Utah

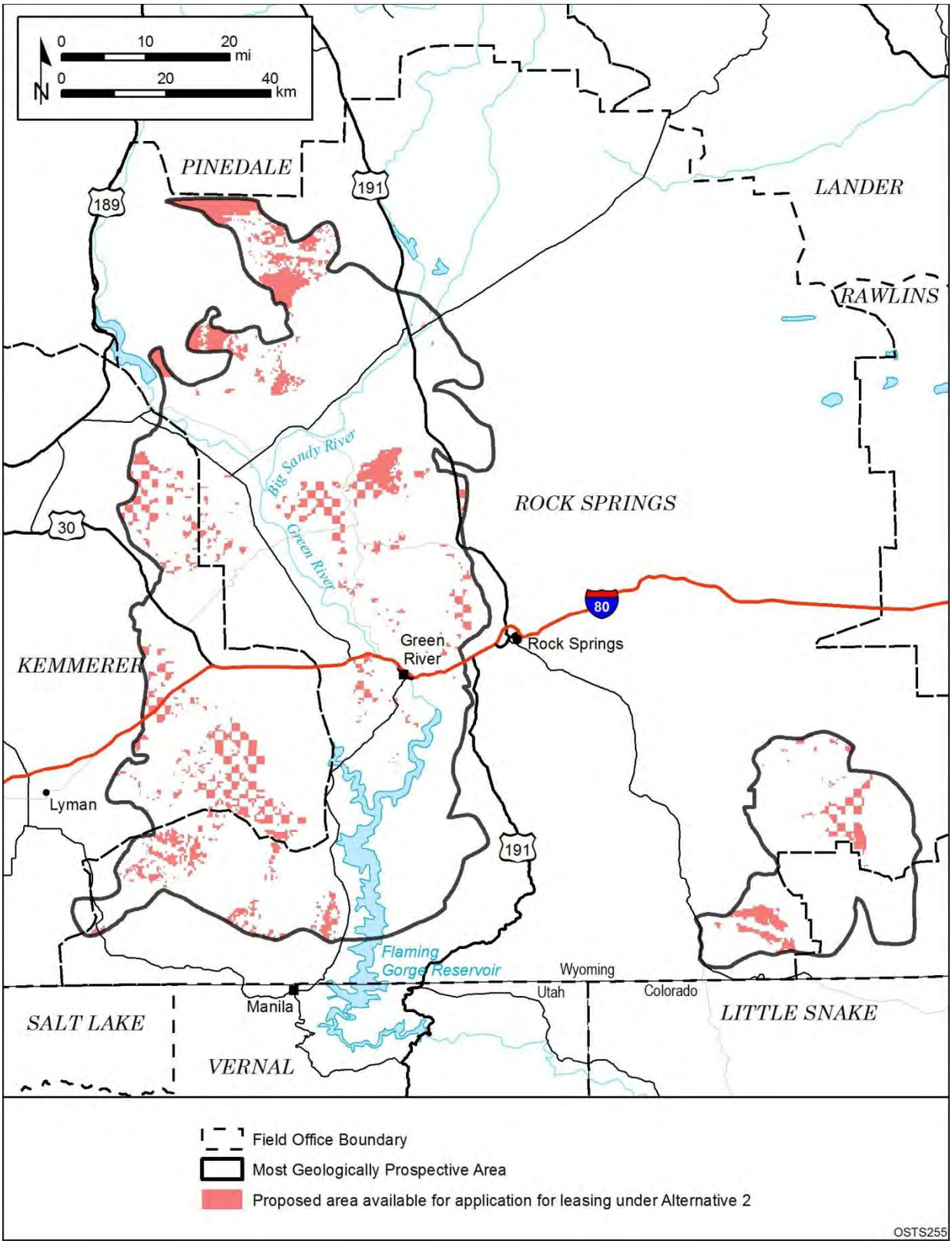

FIGURE 2.3.3-6 Lands Available for Application for Oil Shale Leasing under Alternative 2 in Wyoming

TABLE 2.3.3-1 Estimated Acres Potentially Available in Each State for Application for Leasing for Commercial Oil Shale Development under Alternative 2[a]

State	BLM-Administered Lands	Split Estate Lands	Total
Colorado	23,249	12,059	35,308
Utah	249,041	3,140	252,181
Wyoming	173,388	1,088	174,476
Total for Alternative 2	445,678	16,287	461,965

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS analyses.

Lands included under Alternative 3, the five current RD&D oil shale leases with PRLA lands in Colorado and the current RD&D lease with PRLA land in Utah, are shown in Figures 2.3.2-1 and Figure 2.3.2-2, respectively. Figure 2.3.3-7 shows the locations of the two potential new RD&D oil shale leases in Colorado, along with the five existing RD&D leases in Colorado, and Figure 2.3.3-8 shows the location of the potential new RD&D oil shale lease in Utah.

In Alternative 2, portions of three of the five PRLAs for the Colorado RD&D leases are not identified as available for application for commercial leasing. These include portions of the areas associated with the Chevron, AMSO, and Shell Site 2 RD&D projects. For the other two Colorado RD&D projects, Shell Sites 1 and 3, none of the PRLAs coincide with the area identified as available for application for commercial leasing. For Alternative 3, as is the case for Alternative 1, for the Enefit RD&D project in Utah, the same portion of the area that is not identified as available for lease also is not available for application for commercial leasing under Alternative 3 because of the presence of a potentially eligible WSR, Evacuation Creek (see discussion on this in Section 2.3.3.1).

2.3.3.3 Alternative 4, Oil Shale Moderate Development (2008 OSTS PEIS ROD Minus Adobe Town and ACECs) (Alternative 4a), with RD&D First Requirement (4b)

Under Alternative 4, the BLM would amend 10 land use plans in Colorado, Utah, and Wyoming to designate acreage less than 2,017,714 acres as available for future consideration for leasing for commercial oil shale leasing and less than 430,686 acres as available for application for commercial tar sands leasing.[12] This alternative would exclude from commercial oil shale or tar sands leasing:

[12] This alternative satisfies the settlement agreement to exclude some, but not all, lands from the application of oil shale and tar sands leasing, in comparison to Alternative 2.

TABLE 2.3.3-2 Resources Covered by Stipulations and Restrictions in Place for Oil and Gas Leasing in Each State That Were Used To Identify Lands Not Available for Application for Leasing under Alternative C of the 2008 OSTS PEIS

Colorado
Slopes and erosive/critical soils
Riparian zones and wetlands
Sage-grouse leks and nesting habitat
Raptor nests, roosts, fledgling habitat, and concentration areas
Wildlife habitat[a]
Colorado River cutthroat trout habitat
Listed, proposed, or candidate threatened or endangered and BLM-designated sensitive species
Sensitive plants and remnant vegetation associations
Wild horses and wild horse management areas
Visual Resource Management (VRM) Class II areas
ACECs
Paleontological and cultural resources
Utah
Slopes and erosive critical soils
Floodplains, watersheds, and live water
Sage-grouse leks and nesting habitat
Raptor nests and habitat
Wildlife habitat[a]
Black-footed ferret habitat
Special status plants
ACECs
Paleontological resources
Other[b]
Wyoming
Slopes and fragile/erosive soil
Sage-grouse and greater sage-grouse leks and nesting habitat
Raptor nests and concentration areas
Wildlife habitat[a]
Sensitive species
VRM Class I and II areas
Historic trails
ACECs
Cultural resources
Other[b]

[a] Wildlife habitat includes a combination of winter range, crucial winter range, summer range, and calving areas for antelope, deer, elk, and moose, as well as seclusion areas for other wildlife.

[b] Other resources include Special Management Areas (SMAs), recreation areas, and areas restricted from leasing for reasons not specified in the GIS data.

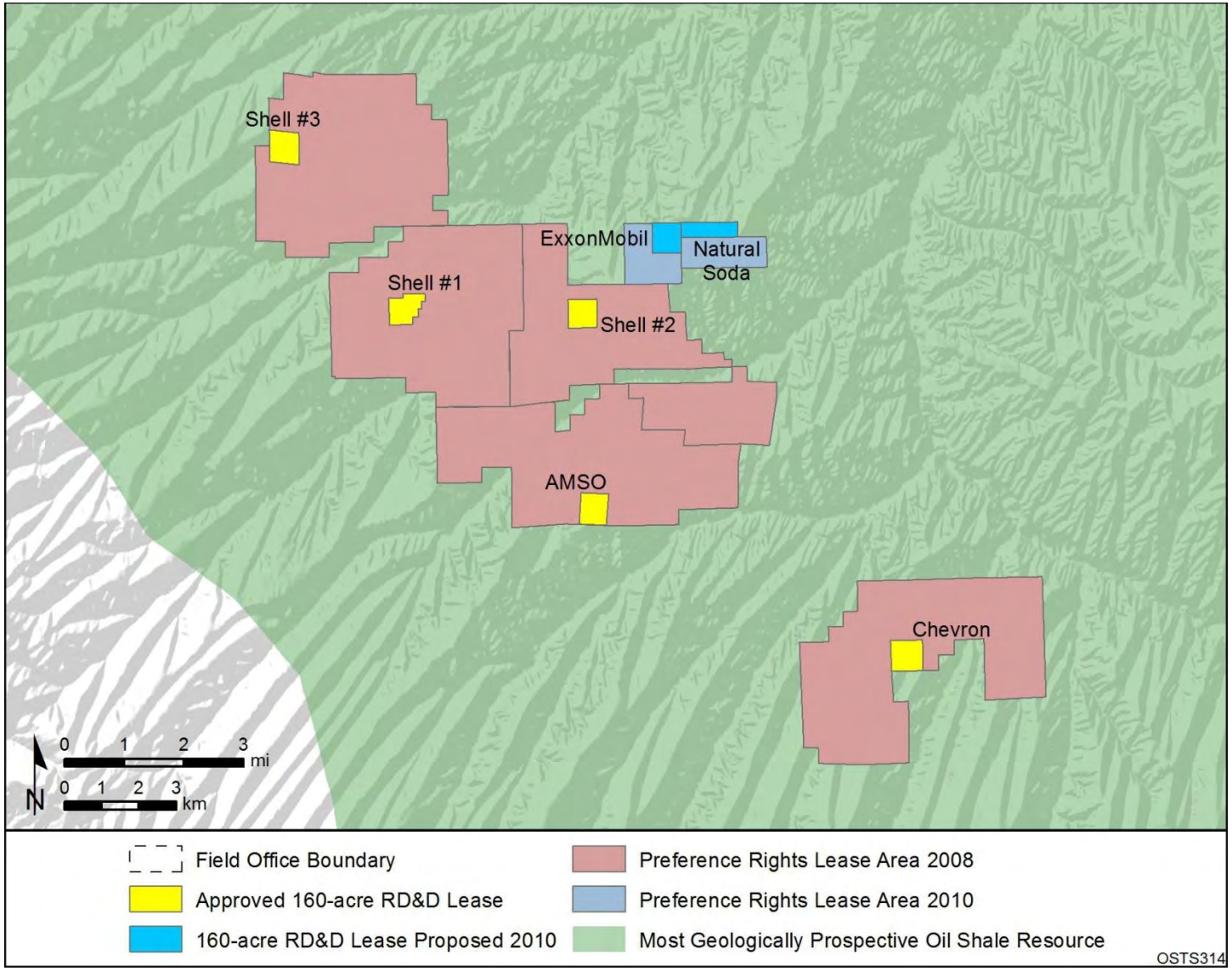

FIGURE 2.3.3-7 Two Potential New RD&D Oil Shale Leases in Colorado (Natural Soda and ExxonMobil) and the Five Existing RD&D Leases in Colorado

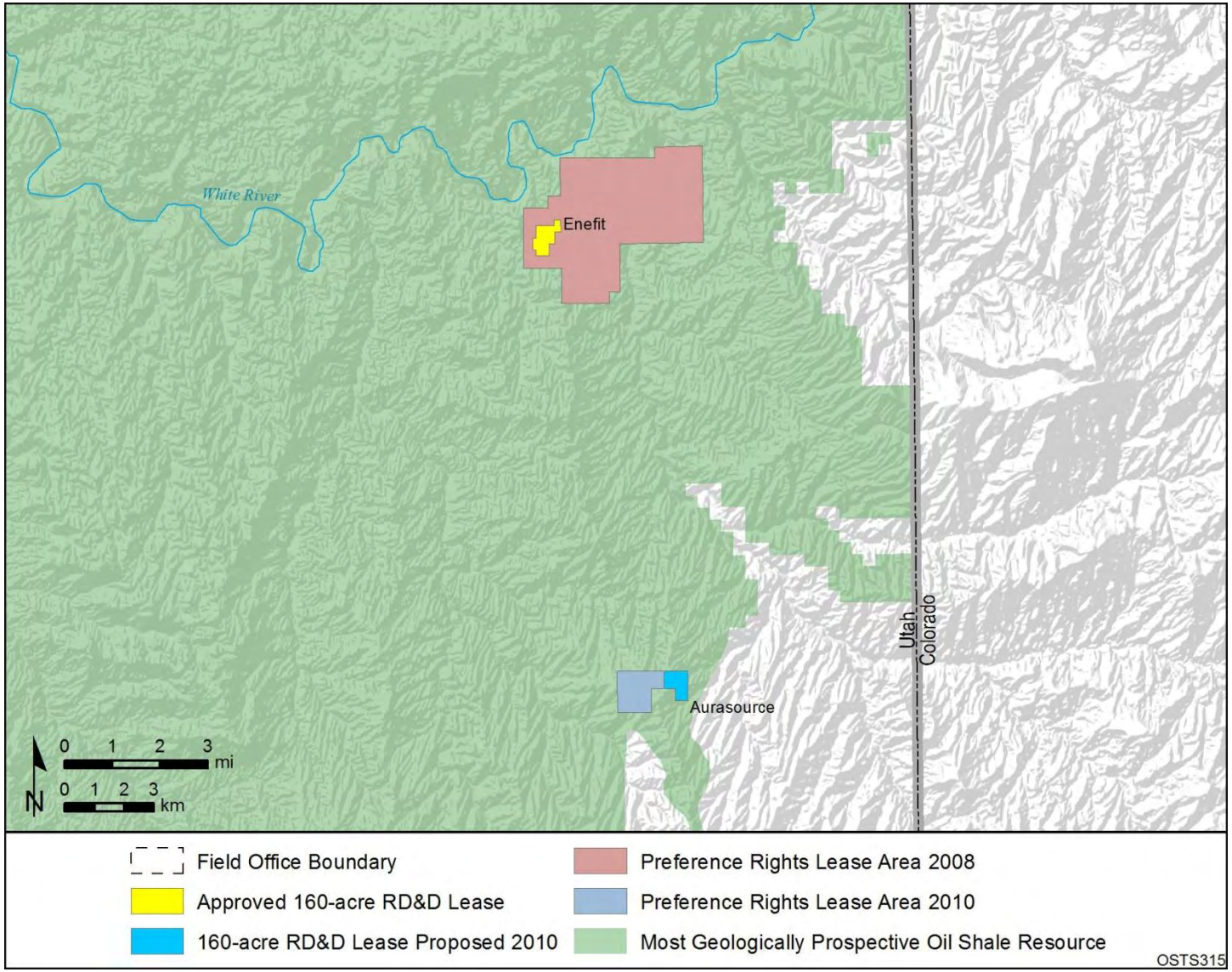

FIGURE 2.3.3-8 Potential New RD&D Oil Shale Lease (Aurasource) in Utah

1. The whole of the Adobe Town "Very Rare or Uncommon" area, as designated by the Wyoming Environment Quality Council on April 10, 2008 (180,910 acres total; 167,517 acres of public land, of which 10,920 acres are already a BLM WSA).

2. All ACECs located within the areas analyzed in the 2008 OSTS PEIS (76,666 acres in existing ACECs in 2008 OSTS PEIS plus additional ACEC acreages as a result of Colorado, Utah, and Wyoming planning efforts recently completed).[13]

RD&D First Requirement (4b). Under this alternative, the lands open for future leasing consideration would be the same as those in Alternative 4(a) but only for RD&D leases. The BLM would issue a commercial lease only when a lessee satisfies the conditions of its RD&D lease and the regulations at 43 CFR Subpart 3926 for conversion to a commercial lease. The preference right acreage, if any, which would be included in the converted lease, would be specified in the RD&D lease.

The environmental impacts of Alternative 4(b) would be analytically indistinguishable from those of Alternative 4(a). Only the method of obtaining a lease would be different. Accordingly, the analysis in this PEIS of Alternative 4 applies fully and equally to both alternatives. To the extent there may be differences in environmental consequences between Alternatives 4(a) and 4(b), these would be related to the timing of commencement of impacts, as well as, possibly, length of disturbance. However, these issues are best addressed in the lease and/or project-specific analysis.

The benefits of Alternative 4(b) would include facilitating a robust RD&D program. It would also avoid allowing a few companies to tie up large areas with speculative commercial leases. Thus it would promote access by innovative small companies to the federal oil shale resource for RD&D.

In the event that a commercially viable technology is demonstrated and becomes widely available in the near future, it is possible that Alternative 4(b) could result in delaying commercial leasing on federal lands. If that possibility, however speculative at the present, were to occur, the pertinent RMPs could be amended contemporaneously with review of proposed commercial leases. The oil shale leasing and management regulations at 43 CFR Part 3900 would not be affected by the selection of any alternative analyzed in this PEIS and thus would remain available for future decisions concerning commercial leasing.

As the Draft PEIS was being developed, the idea for this alternative emerged. It is presented here in brief. This alternative is not noted elsewhere in the document but will be developed further in preparation of the Final PEIS. Analytically, this alternative is indistinguishable from Alternative 4(a) in terms of environmental consequences. Therefore,

[13] This would only include those ACECs that formally designated in those plans. ACECs that were proposed but not formally designated in the applicable plans undergoing revision/amendment at that time would be excluded.

further environmental analysis in preparation of the Final PEIS is not anticipated, although more detailed explanation may be provided, particularly in response to comments received**.**

Under Alternative 4, lands that would be available for future consideration for leasing would include those BLM-administered lands within the most geologically prospective oil shale areas, including split estate lands where the federal government owns the mineral rights. The whole of Adobe Town in Wyoming would be excluded, as would all ACECs, as described above.. Lands available for application for leasing under Alternative 4 are shown in Figures 2.3.3-9, 2.3.3-10, and 2.3.3-11.

Lands within the most geologically prospective oil shale and tar sands areas identified by the BLM as LWC would be managed as in Alternative 1; that is, they would be available for future consideration of leasing and development. Decisions regarding management of these areas would be left to the discretion of the individual field offices to make the leasing decisions, which would determine the management of such areas through additional NEPA and planning processes (as appropriate) with respect to LWC. Thus consideration of management actions for LWC related to oil shale and or tar sands resources would be consistent with what the governing RMP provides with respect to management of such lands for other resources.

Similarly, with respect to the management of sage-grouse habitat, under Alternative 4, lands would be managed as in Alternative 1. No specific decisions regarding core and priority habitat will be made; rather, those decisions will be left up to the individual field offices to make, which would determine the management of such areas through additional NEPA and planning processes (as appropriate) with respect to core and priority sage-grouse habitat, consistent with applicable BLM policies. These policies were described in the 2008 OSTS PEIS (pp. 4-78–4-80) and include BLM's policies and general practices, including specific frequently used mitigation measures, that might be applied to any development, as warranted by analysis at the lease and/or development stage. More recently, the BLM has issued nationwide and state-specific guidance recommending the consideration of certain management practices to address the appropriate management of sage-grouse habitat in the context of land use actions, and this information is presented in a text box in Section 4.8.1 of this PEIS. Field offices would need to take this guidance into account, and incorporate protective measures in any authorizations, as warranted by ecological conditions and on the basis of environmental analysis. As such, it is likely that not all the areas that are currently open under this alternative for potential future leasing would be leased. The maximum acreage developed could be much less than that presented in Table 2.3.3-3, as a result of the application of current BLM policy.

Depending on what the applicable RMP provides with respect to LWC and core and priority sage-grouse habitat, it may be necessary to initiate a plan amendment at the leasing and/or development stage to make allocation decisions on an individual RMP basis regarding management of these lands with respect to oil shale and tar sands resources. The reason for qualifying the amount of acreage available for lease under this alternative is that while areas of core and priority sage-grouse and areas of LWC are left open for potential future leasing and development of oil shale and tar sands resources, the likelihood of all this acreage as being available for further oil shale and tar sands resources leasing and development is low. National and state-specific guidance related to sage-grouse management and protection of core and

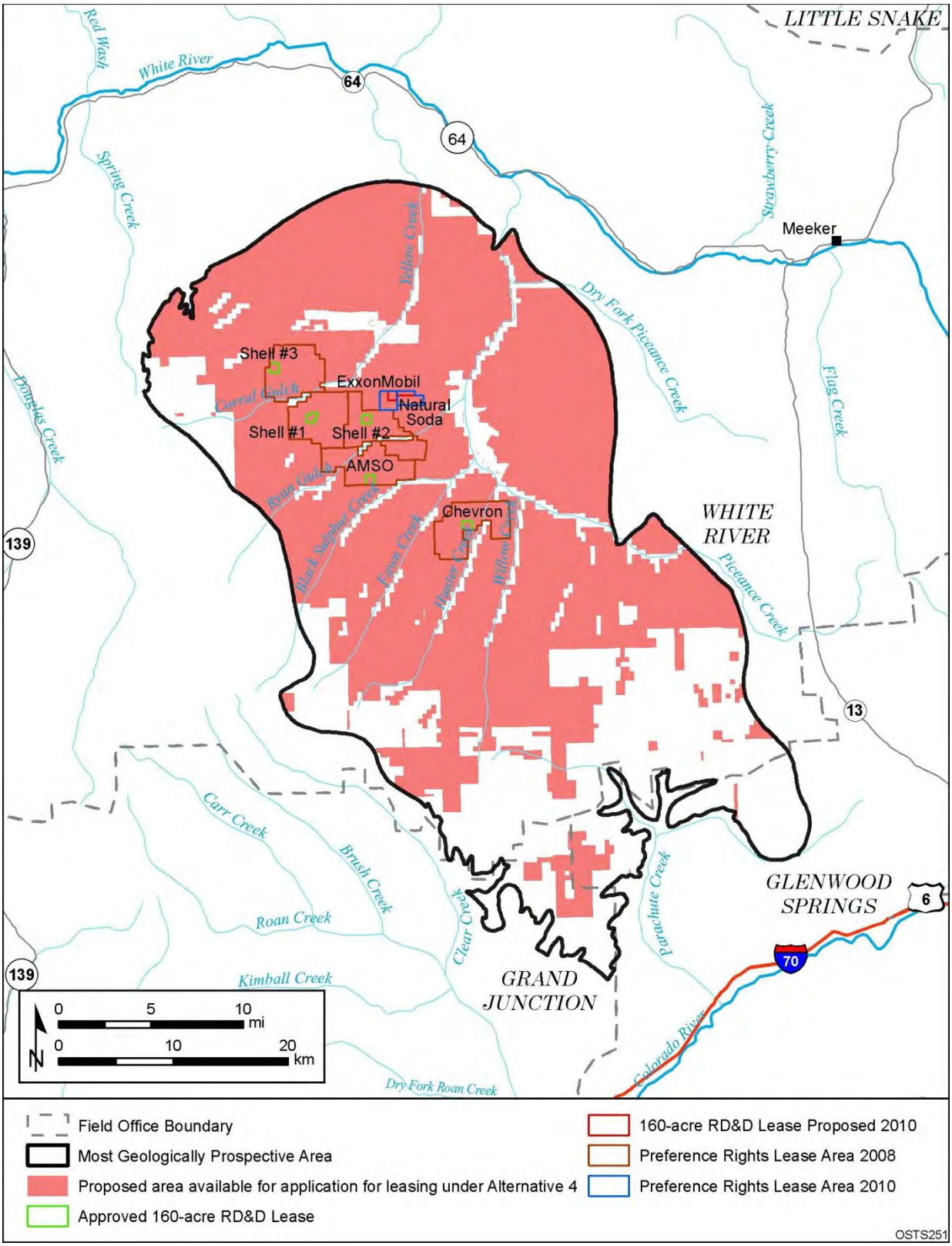

FIGURE 2.3.3-9 Lands Available for Application for Oil Shale Leasing under Alternative 4 in Colorado

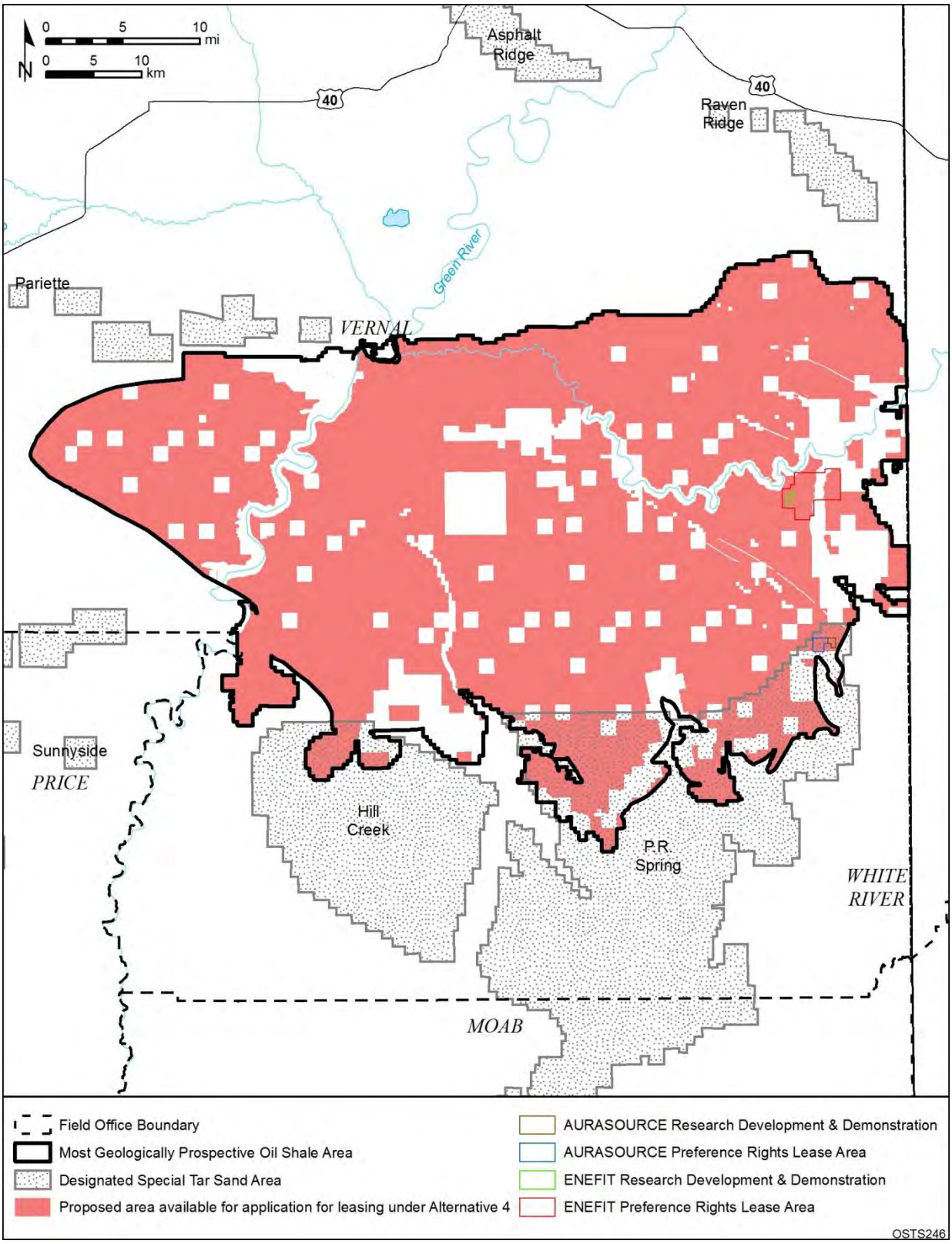

FIGURE 2.3.3-10 Lands Available for Application for Oil Shale Leasing under Alternative 4 in Utah

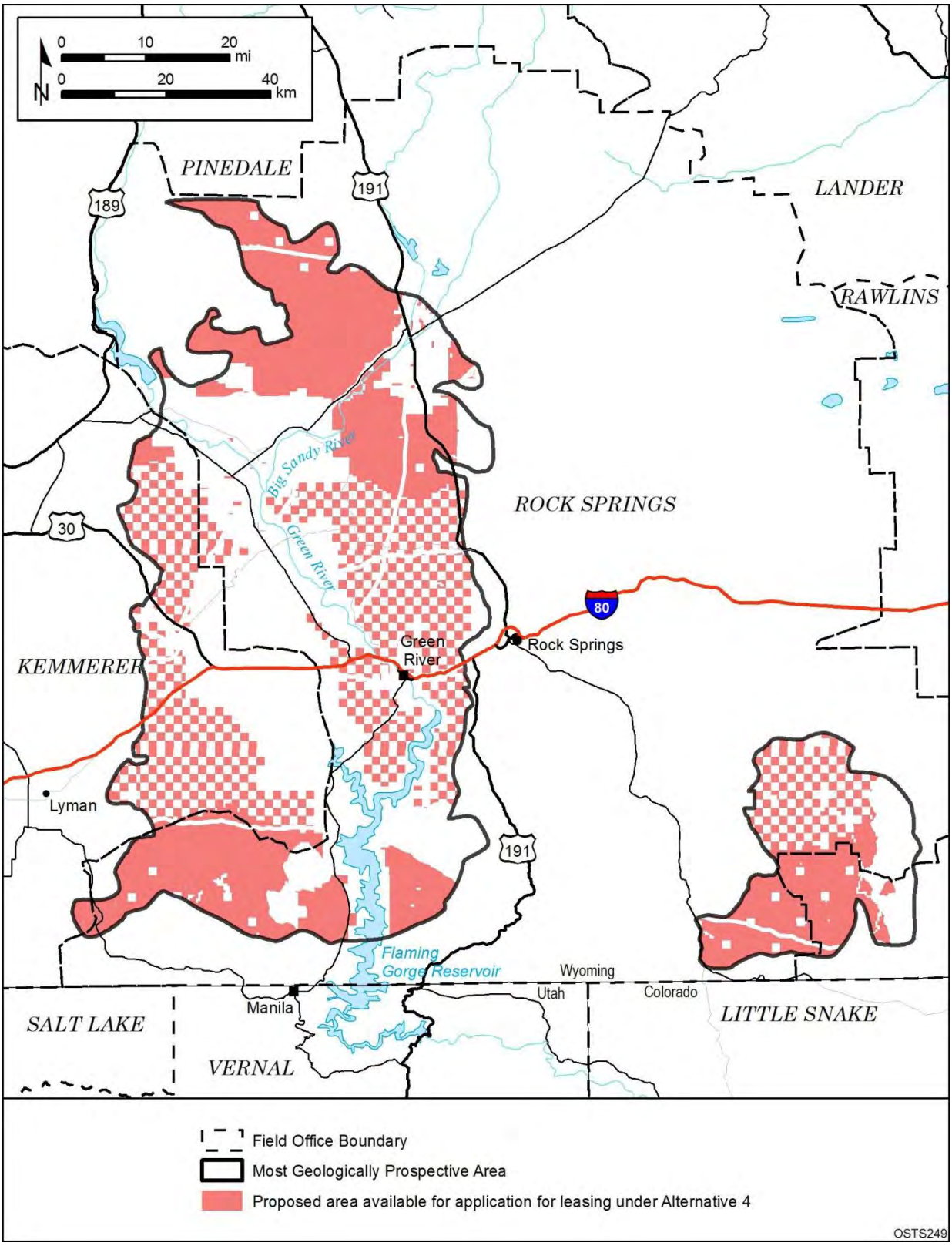

FIGURE 2.3.3-11 Lands Available for Application for Oil Shale Leasing under Alternative 4 in Wyoming

TABLE 2.3.3-3 Estimated Acres Potentially Available in Each State for Application for Leasing for Commercial Oil Shale Development under Alternative 4,[a] Assuming None of the LWC and Sage-Grouse Core and Priority Habitat Are Protected through NSO or No Lease Stipulations

State	BLM-Administered Lands	Split Estate Lands	Total
Colorado	300,718	39,429	340,147
Utah	580,221	75,600	655,821
Wyoming	959,862	7,584	967,446
Total for Alternative 4	1,840,801	122,613	1,963,414

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS analyses. This table assumes NSO/no lease measures are not applied as mitigation to protect LWC or sage-grouse core and priority habitat areas.

priority habitat will likely result in substantially less acreage being available, as will field office management decisions related to the protection of LWC. It is difficult to establish disturbance amounts at the programmatic level, before more is known regarding the specifics of leasehold location and technology to be used. Tables 2.3.3-4 and 2.3.4-5 show what this might look like under different protective scenarios. The scenarios are only provided to illustrate this idea, but the decisions to protect these amounts are not being made at this time as part of this land use plan amendment initiative. These decisions would be made at the field office level as part of the NEPA and/or planning analyses completed for leasing and site-specific development.

As shown in Figures 2.3.3-9, 2.3.3-10, and 2.3.3-11 and reflected in Table 2.3.3-2, a large amount of land (i.e., more than 1,500,000 acres) available for application for leasing under Alternative 4 is excluded under Alternatives 2 and 3. In addition, particularly in Colorado and Wyoming, a large portion of the lands proposed to be available for application for leasing is composed of relatively small, isolated tracts of land. These factors could result in limiting the amount of commercial oil shale development to some level below that which might be realized under Alternative 4.

Also, as discussed in Section 2.3.1, commercial leases for surface mining projects would be allowed only in Utah and Wyoming on those lands where the overburden is 0 to 500 ft thick. In Utah, under Alternative 4, lands available for application for leasing for surface mining projects total about 46,900 acres in the Vernal RMP planning area. In Wyoming, under Alternative 4, these lands total about 68,200 acres in the Green River RMP planning area.

TABLE 2.3.3-4 Estimated Acres Potentially Available in Each State for Application for Leasing for Commercial Oil Shale Development under Alternative 4, Assuming 75% of the LWC and Sage-Grouse Core and Priority Habitat Are Protected through NSO or No Lease Stipulations

State	Acres LWC and Sage-Grouse[a]	BLM-Administered Lands	Split Estate Lands	Total
Colorado	24,436	282,547	38,524	321,071
Utah	263,200	393,843	64,578	458,421
Wyoming	366,091	686,696	6,182	692,878
Total for Alternative 4	653,727	1,363,086	109,284	1,472,270

[a] Acreage that is identified as either LWC or sage-grouse core or priority habitat or both within Alternative 4.

TABLE 2.3.3-5 Estimated Acres Potentially Available in Each State for Application for Leasing for Commercial Oil Shale Development under Alternative 4, Assuming 25% of the LWC and Sage-Grouse Core and Priority Habitat Are Protected through NSO or No Lease Stipulations

State	BLM-Administered Lands	Split Estate Lands	Total
Colorado	294,662	39,127	333,789
Utah	518,095	71,926	590,021
Wyoming	868,807	7,116	875,923
Total for Alternative 4	1,681,564	118,169	1,799,733

In Alternative 2, portions of three of the five PRLAs for the Colorado RD&D leases are not identified as available for application for commercial leasing. These include portions of the areas associated with the Chevron, AMSO, and Shell Site 2 RD&D projects. For the other two Colorado RD&D projects, Shell Sites 1 and 3, none of the PRLAs coincide with the area identified as available for application for commercial leasing. For Alternative 4, as is the case for Alternative 1, for the Enefit RD&D project in Utah, the same portion of the area that is not identified as available for lease also is not available for application for commercial leasing under Alternative 4 because of the presence of a potentially eligible WSR, Evacuation Creek (see discussion on this in Section 2.3.3.1).

Under the terms of the RD&D program, the federal government has a commitment to grant the RD&D companies leases for commercial development within the PRLAs, provided that all terms and conditions of the leases are met (see Section 1.4.1). As a result, all lands within the PRLAs would be available for issuance of commercial leases to the current RD&D lessees, subject to their lease requirements.

2.4 TAR SANDS

Tar sands are sedimentary rocks containing bitumen, a heavy hydrocarbon complex. Lighter, more volatile hydrocarbons once present in these rocks have escaped to the environment, leaving the heavier, less volatile bitumen in place. Because of the very viscous nature of the bitumen, tar sands cannot be processed by normal petroleum production techniques.[14]

More than 50 tar sands deposits occur in Utah. Limited data are available on many of these deposits, and most of the known bitumen occurs in just a few of the deposits. The deposits that are being evaluated in this PEIS are those classified in the 11 sets of geologic reports (minutes) prepared by the USGS in 1980 (USGS 1980a–k) and formalized by Congress in the Combined Hydrocarbon Leasing Act of 1981 (P.L. 97-78).[15] The 11 STSAs, which define the tar sands study area, are shown in Figure 2.4-1 and listed in Table 2.4-1, along with their total size in acres and the number of acres of BLM-administered and split estate lands within each STSA. These STSAs are considered to be the most geologically prospective areas for tar sands development.

Although no tar sands development is currently taking place on public lands in Utah, the BLM does have a pending application for a tar sands lease. In the mid-1980s, a number of CHLs were issued in the Pariette and P.R. Spring STSAs under the authority of the Combined Hydrocarbon Leasing Act (P.L. 97-78). These include four leases in the Pariette STSA and two leases in the P.R. Spring STSA; these leases remain in existence. Also in the mid-1980s, a number of operators holding oil and gas leases or tar sands claims within designated STSAs applied to convert their leases to CHLs. In most instances, the conversion of these leases has not been completed; thus, a number of pending conversion applications remain within the study area, specifically within the Circle Cliffs, Tar Sand Triangle, and P.R. Spring STSAs.[16] The BLM is currently engaged in adjudication of these leases.[17] Tar sands deposits outside the areas

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[14] "Tar sands" should be distinguished from the "oil sands" found in Canada. The differences between these two resources and the resulting differences in how they might be developed are discussed in Appendix B.

[15] See 30 USC 181, which defines "special tar sands area" as an area designated by the Secretary of the Interior's orders of November 20, 1980 (45 FR 76800–76801) and January 21, 1981 (46 FR 6077–6078).

[16] While the Circle Cliffs STSA is a designated STSA, the BLM-administered portion of it falls entirely within the GSENM and has been excluded from consideration for being designated as open to application for leasing in this PEIS.

[17] Decisions in this PEIS and its accompanying ROD regarding the availability of lands within the STSAs for future commercial leasing and the constraints under which such future leases would be issued would not affect the existing CHLs or any of the pending applications that are converted to CHLs.

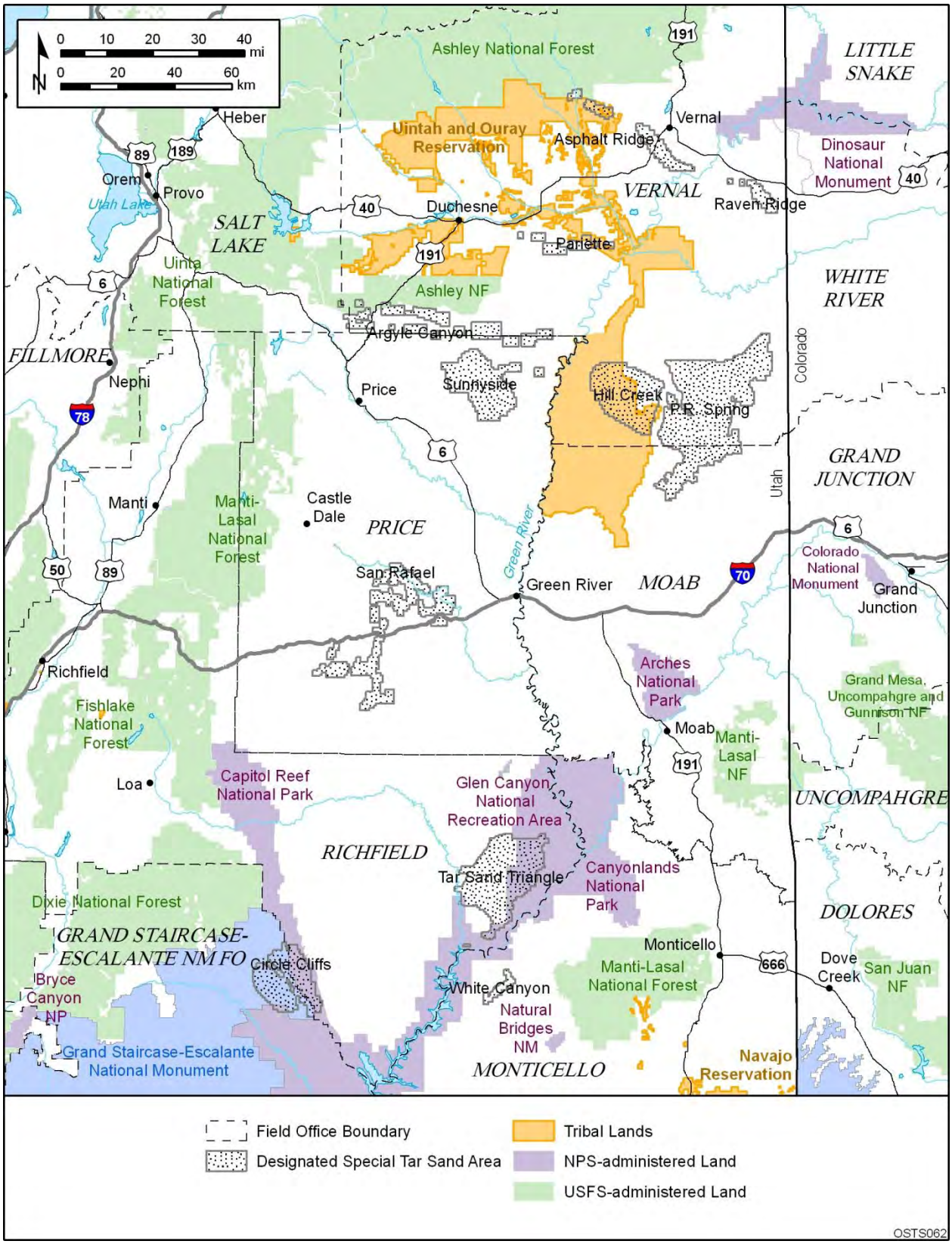

FIGURE 2.4-1 Special Tar Sand Areas in Utah

TABLE 2.4-1 Total Size in Acres of the 11 STSAs and Acres of BLM-Administered and Split Estate Lands within Each STSA[a,b]

STSA	Total Size	Total BLM-Administered Lands within STSA	Total Split Estate Lands within STSA
Argyle Canyon	22,259	1,224	11,869
Asphalt Ridge	39,151	5,324	128
Circle Cliffs[c]	91,303	50,852	6,707
Hill Creek[d]	106,795	19,826	36,583
Pariette	22,622	12,336	78
P.R. Spring	273,922	184,100	7,639
Raven Ridge	16,533	14,352	16
San Rafael Swell	130,737	115,665	0
Sunnyside	157,406	78,676	18,175
Tar Sand Triangle	155,049	82,208	0
White Canyon	10,490	8,050	0
Total	1,026,266	572,613	81,196

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for 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] The Circle Cliffs STSA is included for information purposes only; it has been excluded from consideration for being designated as open to application for leasing in this PEIS. The BLM-administered lands fall entirely within the GSENM.

[d] The split estate lands in the Hill Creek STSA include 35,472 acres of split estate lands within the Hill Creek Extension of the Uintah and Ouray Reservation on which the surface rights are owned by the Ute Indian Tribe.

designated by the Secretary of the Interior in the 11 sets of minutes are not available for leasing under the CHL Program, but are available for development under a conventional oil and gas lease.

Potential tar sands development could occur on the existing CHLs or on pending conversion leases should they be converted to CHLs.

2.4.1 Potential Commercial Tar Sands Development Technologies

This section briefly describes the tar sands development technologies that have been considered in the scope of the PEIS analyses. Appendix B provides a more detailed discussion of potential technologies that may be used over the next 20 years and includes a discussion of oil sands development in Canada. Information presented in this section and Appendix B on

technologies that might be used is taken from the best available published data. Because commercial tar sands development is still evolving, many details regarding the specific technologies that will be used in the future to produce oil from tar sands are unknown. In the absence of complete and definitive information about the technologies that may be deployed, a number of assumptions have been made. These assumptions are discussed in Section 5.1.

Commercial development of a tar sands resource occurs in three major steps: (1) recovery of the bitumen in its natural setting, (2) processing of the bitumen to extract it from the inorganic matrix (largely sand and silt) in which it occurs, and (3) upgrading of the bitumen to produce a synthetic crude oil suitable as a feedstock for a conventional refinery. The physical and chemical features of the tar sands deposits and other circumstantial factors associated with their deposition dictate the most appropriate development schemes. Typical development schemes always involve each of the above major steps, although many permutations of these steps are possible and many interim steps may also be necessary.

Recovery methods can be categorized as either mining activities or in situ processes, although some techniques involve a combination of recovery methods. Mining consists of using surface or subsurface mining techniques to excavate the tar sands with subsequent recovery of the bitumen by washing, flotation, or retorting.[18] True in situ methods generally involve either heating the tar sands (referred to as in situ combustion) or injecting materials (e.g., steam, hot water, gas, or solvents) into them to mobilize the bitumen for recovery. Depending on production costs and the price of the synthetic crude produced, surface mining operations are generally cost-effective only where the overburden is no more than about 45 m (150 ft) (Meyer 1995). In situ processes requiring high pressures are generally considered to require a thick overburden of about 150 m (500 ft) to contain the pressure. Between these depths, bitumen must be recovered by other means.

The choice of recovery method affects which extraction and processing operations are used. In mining operations, the mined bitumen must be processed to recover or separate it from the inorganic matrix (largely sand, silt, and clay) in which it occurs. Nonmining recovery methods produce bitumen mixed with water, steam, other gases, or solvent from which it must be separated. If combustion recovery is used, the viscosity of the recovered bitumen may need to be reduced prior to further processing. In all cases, the viscosity of the bitumen might need to be changed prior to further processing and upgrading (BLM 1984). Depending on the recovery method, mining operations may also need to perform similar separations. The recovery processes evaluated in this PEIS include those discussed in Appendix B: the hot water process, cold water process, solvent extraction process, and thermal recovery processes, including retorting.

Irrespective of the recovery and processing technologies employed, it is assumed that in most commercial projects the recovered bitumen would need to be upgraded in order for it to be accepted by oil refineries as feedstock for conventional fuels. Although there are variations among different production operations, four main processes are used to upgrade bitumen: coking (thermal conversion), catalytic conversion, distillation (fractionation), and hydrotreating.

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[18] The PEIS does not evaluate the application of underground mining technologies for the commercial development of tar sands because, at this time, underground mining to develop tar sands does not appear to be commercially viable.

Four technology combinations are evaluated in this PEIS for commercial tar sands development:

- Surface mining projects with surface retorting,
- Surface mining projects with solvent extraction,
- In situ steam injection projects, and
- In situ combustion projects.

While many hypothetical development scenarios could be constructed for various technology combinations, it is not possible to project or analyze all of them in this PEIS.

For the same reasons the BLM has elected not to attempt to issue leases on the basis of the NEPA analysis in this PEIS (see Section 2.5.1). This PEIS does not include analysis of a particular development scenario. Because the tar sands industry in the United States still lacks a commercially implemented technology, the BLM concluded that trying to anticipate a certain level of development would be too speculative.

Therefore, this PEIS includes description and analysis not of a particular level of development, but of the possible impacts of each type of technology that has been considered and researched, so far as this information is available to the BLM at this time.

In all allocation alternatives, including the No Action Alternative, RD&D leases could be issued in any areas opened to commercial tar sands leasing. While there has never yet been any formal RD&D program for tar sands leasing, and there is no present intention to establish such a program, nevertheless, RD&D projects might precede commercial tar sands leasing or might be conducted contemporaneously with commercial leasing and operations. Impacts from RD&D projects are anticipated to be qualitatively similar but smaller in scale than those of commercial projects, at least until any RD&D lease might be converted to a commercial tar sands lease and expanded to include preference right acreage. Additional NEPA analysis would be required prior to issuance of any RD&D lease and prior to conversion of an RD&D lease to a commercial tar sands lease and expansion into a PRLA.

If and when applications to lease are received and additional information becomes available, the BLM will conduct NEPA analyses, including consideration of direct, indirect, and cumulative effects, reasonable alternatives, and possible mitigation measures, as well as what level of development may be anticipated. On the basis of that NEPA analysis to be conducted at the lease stage, the BLM will consider the establishment of general lease stipulations and BMPs, either by further plan amendment, if necessary, or by other means.

This PEIS considers the components of current technologies that could be implemented in order to analyze the range of potential impacts that could occur. The scope of the PEIS analyses is intended to be broad enough to include the potential array of technologies that might be used to commercially develop tar sands resources on public lands. It is possible, however, that

additional technologies may be identified as viable in the next 20 years. The application of such technologies on public lands may be allowed by the BLM; however, these technologies would need to be evaluated on a case-by-case basis.

2.4.2 Alternative 1, Tar Sands No Action Alternative, No Change to 2008 Decision

Under this alternative, no existing land use plans would be amended. In 2008, the BLM designated a total of 430,686 acres available for applications for commercial tar sands leasing. The lands available for lease under the 2008 land use plan amendment decisions would remain available for future leasing consideration under Alternative 1, no action. See Section 2.3.2 for a full description of the No Action Alternative. Figure 2.4.2-1 shows the lands available for application for leasing under Alternative 1. Table 2.4.2-1 shows the acreages by STSA. Table 2.4.2-2 provides a summary of the activities and conditions assumed to occur under Alternative 1 relevant to tar sands leasing.

2.4.3 Commercial Tar Sands Land Allocation Alternatives

The three new allocation action alternatives that the BLM has developed for establishing a commercial tar sands program are also summarized in Table 2.4.2-2. These new allocation alternatives, labeled Alternatives 2, 3, and 4, consist of different management approaches to future commercial tar sands leasing. Under all allocation alternatives, including the No Action Alternative, the BLM proposes to make certain lands within the STSAs available for application for commercial leases and certain lands unavailable. Under all alternatives, additional NEPA and other appropriate analyses would be conducted prior to the issuance of commercial leases. In addition, site-specific NEPA and other appropriate analyses would be conducted during evaluation and approval of plans of development during the project development phase. These site-specific analyses, which potentially could be combined into a single NEPA evaluation, would identify potential project-specific impacts and define appropriate lease stipulations and required mitigation measures. The potentially applicable mitigation measures discussed in the Chapter 5 impact analyses would be applied during the site-specific analyses, as appropriate.

As discussed in Section 1.2, the BLM has determined that certain lands within the STSAs are excluded from commercial leasing under all alternatives, on the basis of existing laws and regulations, E.O.s, land use plan designations, and other administrative designations or withdrawals. As a result, commercial leasing is excluded from all designated Wilderness Areas, WSAs, and other areas that are part of the NLCS administered by the BLM (e.g., National Monuments, NCAs, WSRs, and National Historic and Scenic Trails). Leasing also would be excluded from all existing ACECs and lands within incorporated town and city limits. The BLM has also determined that additional areas would be closed and would not be available for future opportunity to lease for commercial development of tar sands resources under all allocation action alternatives. These additional areas include:

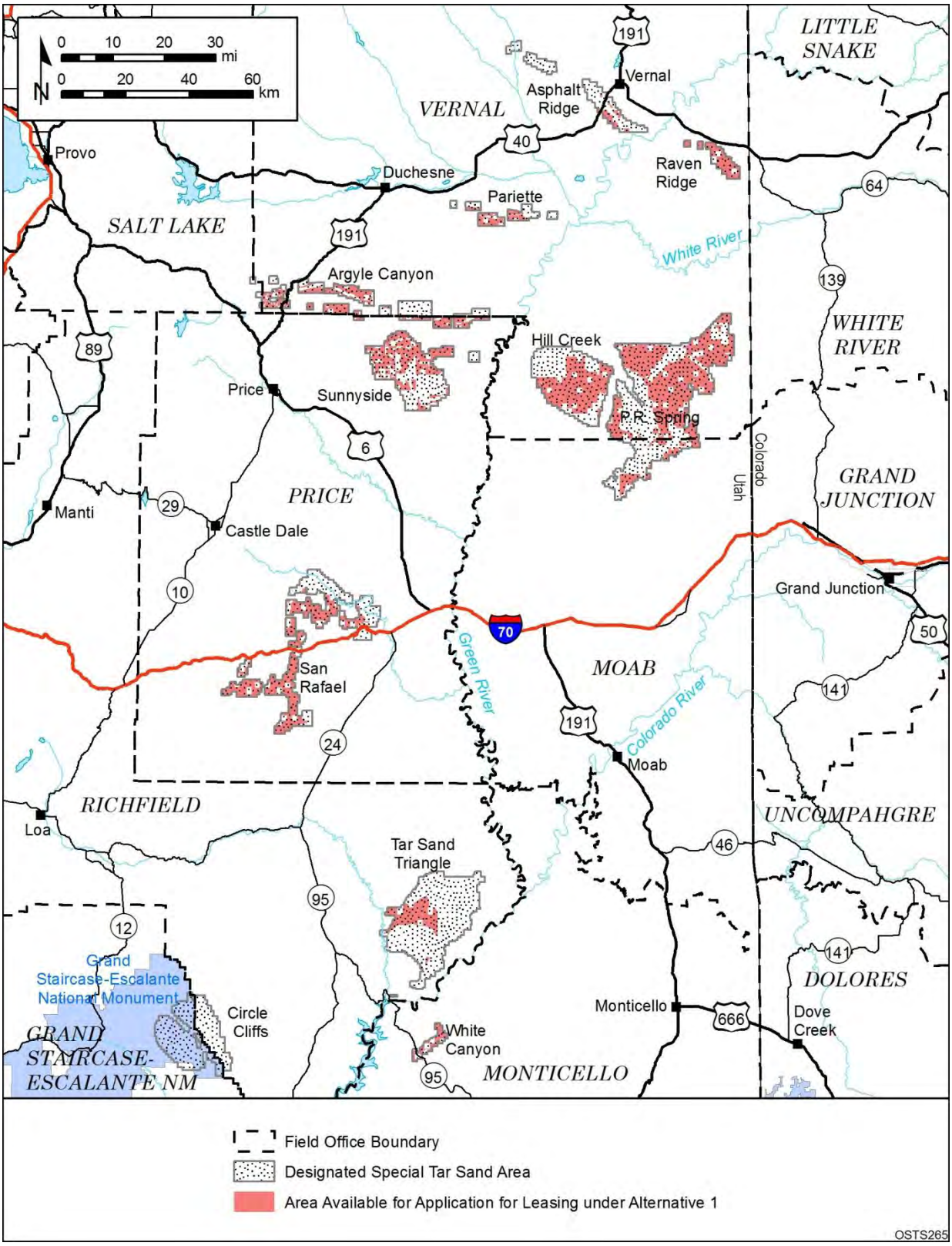

FIGURE 2.4.2-1 Lands Available for Application for Tar Sands Leasing under Alternative 1 for Commercial Tar Sands Development within the STSAs in Utah

TABLE 2.4.2-1 Estimated Acres Potentially Available under Alternative 1 for Application for Leasing in Each STSA for Commercial Tar Sands Development[a]

STSA	BLM-Administered Lands	Split Estate Lands	Total
Argyle Canyon	1,022	10,204	11,226
Asphalt Ridge	5,310	125	5,435
Circle Cliffs[b]	0	0	0
Hill Creek	19,924	36,583	56,507
Pariette	10,083	78	10,161
P.R. Spring	145,922	6,694	152,617
Raven Ridge	14,348	16	14,364
San Rafael	70,475	0	70,475
Sunnyside	61,338	16,624	77,962
Tar Sand Triangle	24,938	0	24,938
White Canyon	7,001	0	7,001
Total for Alternative 1	360,362	70,324	430,686

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS analyses.

[b] Leasing for commercial tar sands development in the Circle Cliffs STSA is excluded under all alternatives because it falls entirely within the GSENM and units managed by the NPS on which mineral leasing and development are prohibited.

- *Circle Cliffs STSA.* Most of the Circle Cliffs STSA falls entirely within the GSENM and Capitol Reef National Park. The issuance of new leases for mineral development within each of these units is prohibited. Also, a small portion of the Circle Cliffs STSA underlies the Glen Canyon NRA; this area is part of the "Natural Zone" within which mineral leasing and development are prohibited.

- *Segments of rivers that have been determined to be potentially eligible for WSR status by virtue of a WSR inventory*. These river segments and a corridor extending at least 0.25 mi on either side of these segments would be excluded from commercial leasing.

Leasing would occur as set forth in 43 CFR Part 3140. For information purposes, the process could be summarized as follows. The BLM would hold a competitive lease sale as provided for in 43 CFR 3141.1. A potential lessee could submit a request or expression of interest in one or more tracts for competitive lease offering as provided for in 43 CFR 3141.6-1. The BLM anticipates that it will need additional information about potential technologies for, and impacts from, commercial production of tar sands in order to complete an analysis under NEPA, NHPA, ESA, and other appropriate laws, policies, and regulations for issuing leases or

TABLE 2.4.2-2 Summary of Activities and Conditions Assumed for Each of the Tar Sands Alternatives

Condition	Alternative 1 (No Action)	Alternative 2 (Conservation Focus)	Alternative 3 (Pending Commercial Lease)	Alternative 4 (Moderate Development)
Land use plans amended	No plans would be amended.	Four plans would be amended.	Same as Alternative 2.	Same as Alternative 2.
Potential area made available for application for leasing (RD&D and commercial leases)	430,686 acres would be available for application for commercial lease. Argyle Canyon: 11,226 acres Asphalt Ridge: 5,435 acres Circle Cliffs: 0 acres Hill Creek: 56,507 acres Pariette: 10,161 acres P.R. Spring: 152,617 acres Raven Ridge: 14,364 acres San Rafael: 70,475 acres Sunnyside: 77,962 acres Tar Sand Triangle: 24,938 acres White Canyon: 7,001 acres	91,045 acres would be available for application for commercial lease. Argyle Canyon: 0 acres Asphalt Ridge: 0 acres Circle Cliffs: 0 acres Hill Creek: 9,835 acres Pariette: 830 acres P.R. Spring: 42,304 acres Raven Ridge: 9,119 acres San Rafael: 8,927 acres Sunnyside: 19,888 acres Tar Sand Triangle: 97 acres White Canyon: 45 acres	The pending Asphalt Ridge lease application south of Vernal, Utah covering approximately 2,100 acres.	276,708 t0 425,790[a] acres would be available for application for commercial lease. Argyle Canyon: 11,215 to 11,226 acres Asphalt Ridge: 1,387 to 5,435 acres Circle Cliffs: 0 acres Hill Creek: 53,372 to 62,152 acres Pariette: 10,161 acres P.R. Spring: 108,922 to 152,617 acres Raven Ridge: 12,643 to 14,364 acres San Rafael: 26,147 to 69,696 acres Sunnyside: 42,946 to 68,200 acres Tar Sand Triangle: 6,570 to 24,938 acres White Canyon: 3,345 to 7,001 acres
Technologies considered	Surface mining with surface retort Surface mining with solvent extraction In situ steam injection In situ combustion	Surface mining with surface retort Surface mining with solvent extraction In situ steam injection In situ combustion	Same as Alternative 1.	Same as Alternative 1.

TABLE 2.4.2-2 (Cont.)

Condition	Alternative 1 (No Action)	Alternative 2 (Conservation Focus)	Alternative 3 (Pending Commercial Lease)	Alternative 4 (Moderate Development)
Lands excluded from commercial leasing	Wilderness Areas, WSAs, other areas that are part of the NLCS. • All ACECs existing as of the signing of the 2008 ROD. • The Circle Cliffs STSA. • Historic trails. • Segments of rivers determined to be eligible for WSR status by virtue of a WSR inventory. • Incorporated town and city limits.	Same as Alternative 1, plus: • Lands with wilderness characteristics • Adobe Town "Very Rare or Uncommon" area. • Core or priority sage-grouse habitat. • ACEC acreage both added since the 2008 OSTS PEIS ROD and under consideration for designation. • Areas excluded under Alternative C of the 2008 OSTS PEIS not included in Alternative 1.	All areas except the pending Asphalt Ridge lease application.	Same as Alternative 1 plus Adobe Town "Very Rare and Uncommon" area in Wyoming and ACEC acreage added in planning efforts in Utah and Wyoming since the 2008 OSTS PEIS ROD, as well as areas under consideration for designation as ACECs in current planning processes.
Regulatory and operational constraints	All commercial development would be conducted in compliance with existing federal, state, and local regulatory requirements and established BLM policies.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Additional NEPA requirements	Additional NEPA analyses would be required before any leases for commercial development could be issued. Site-specific NEPA analyses also would be conducted during the review and approval of project plans of development.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

TABLE 2.4.2-2 (Cont.)

Condition	Alternative 1 (No Action)	Alternative 2 (Conservation Focus)	Alternative 3 (Pending Commercial Lease)	Alternative 4 (Moderate Development)
Applicable leasing regulations	Leasing (including CHLs) would be conducted pursuant to the regulations pertaining to tar sands leasing at 43 CFR Part 3140.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

Abbreviations: ACEC = Area of Critical Environmental Concern; BLM = Bureau of Land Management; CFR = *Code of Federal Regulations*; CHL = combined hydrocarbon lease; DOI = U.S. Department of the Interior; NLCS = National Landscape Conservation System; NEPA = National Environmental Policy Act; NOSR = Naval Oil Shale Reserves; OSTS = oil shale and tar sands; RD&D = research, development, and demonstration; ROD = Record of Decision; STSA = Special Tar Sand Area; WSA = Wilderness Study Area.

[a] This range corresponds to 75% protection of LWC and sage-grouse core and priority habitat at the low end to no protection at the high end.

approving plans of developments. That information does not presently exist and would likely need to come from the industry before the BLM would proceed with leasing or approval of operations.

Under all allocation action alternatives, the BLM would ensure that the operator conducts commercial development in compliance with existing federal, state, and local regulatory requirements and established BLM policies, as generally described in Section 2.2 and Appendix D. That compliance would include, as appropriate, obtaining all permits (e.g., air, water, and waste management) as required by regulatory agencies; operating within the permit constraints; completing consultation with the USFWS under Section 7 of the ESA; completing consultation with SHPOs, Tribal Historic Preservation Officers, and other consulting parties under Section 106 of the NHPA; and compliance with any other relevant and applicable requirements. Compliance-related conditions would be developed on a project-by-project basis during site-specific analyses.

Under each of the three new allocation action alternatives, four land use plans in Utah would be amended to redesignate lands within the STSAs as available or not available for application to lease. The plans that would be amended to address commercial tar sands leasing and development include the following:

- Monticello RMP (BLM 2008d);
- Price RMP (BLM 2008e);
- Richfield RMP (BLM 2008f); and
- Vernal RMP (BLM 2008g).

Public lands outside of the STSAs are not being excluded from consideration for leasing for any environmental or other specific reason and could be considered for application for leasing at a later time but would require consideration in a new NEPA analysis and a land use plan amendment before leasing could be authorized. Areas within the STSAs that are excluded from consideration for application for leasing in the current PEIS, or environmentally and economically sound proposals employing different technologies, could also be considered in the future.

The following sections describe the new allocation action alternatives evaluated in this PEIS. The sections identify the additional leasing exclusions that the BLM has identified for each alternative and the proposed land use plan amendments. The specific land use plan amendments are discussed in greater detail in Appendix C.

2.4.3.1 Alternative 2, Tar Sands Conservation Focus

Under the terms of the 2011 settlement of the litigation over the 2008 oil shale and tar sands plan amendment (USDC, Colorado, February 15, 2011 [USDC Colorado 2011]), the DOI

and BLM agreed to analyze an alternative that excludes from oil shale and tar sands leasing and development all of the resource types listed below. Under this alternative, six land use plans in Utah would be amended to designate less than 229,000 acres (acreage opened under Alternative C of the 2008 plan amendment) as available for future commercial tar sands leasing.[19] This alternative would exclude from commercial tar sands leasing the following categories or groups of categories of public lands and/or their resource values that may warrant protection from potential oil shale leasing and development:

1. All areas that the BLM has identified or may identify as a result of inventories conducted during this planning process, as LWC;

2. The whole of the Adobe Town "Very Rare or Uncommon" area, as designated by the Wyoming Environment Quality Council on April 10, 2008 (180,910 acres total; 167,517 acres of public land, of which 10,920 acres are already a BLM WSA);

3. Core or priority sage-grouse habitat, as defined by such guidance as the BLM or the DOI may issue;

4. All ACECs located within the areas analyzed in the 2008 OSTS PEIS (76,666 acres in existing ACECs in the 2008 OSTS PEIS plus additional ACEC acreages as a result of Utah and Wyoming planning efforts recently completed), as well as all areas under consideration for designation as ACECS in planning processes currently underway; and

5. All areas identified as excluded from commercial oil shale and tar sands leasing in Alternative C of the September 2008 OSTS PEIS (Alternative C made 830,296 acres available for potential commercial oil shale leasing and 229,038 acres available for potential commercial tar sands leasing).[20]

Specifically, under Alternative 2, the BLM proposes to designate a total of 91,045 acres available for commercial tar sands leasing by amending two land use plans to adopt the conditions and constraints discussed above and in accordance with applicable federal, state, and local regulations and BLM policies. The lands that would be available for application include all BLM-administered public lands within the STSAs, including split estate lands where the federal government owns the mineral rights, except those lands described above and in Section 2.4.3.

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[19] In a February 15, 2011, settlement of a lawsuit brought by several environmental advocacy groups challenging the 2008 OSTS PEIS and ROD, the DOI and BLM agreed to analyze an alternative that considers excluding from oil shale/tar sands leasing and development all lands containing the resource types listed, as well as an alternative that considers excluding from oil shale/tar sands leasing and development some portion of the lands containing the resource types listed. The latter alternative is represented by Alternative 4, the Moderate Development Alternative, described below.

[20] This would include analysis of excluding from future oil shale and tar sands leasing not only all ACECs, but also areas that had been under consideration for designation as ACECs in the applicable plans undergoing revision or amendment at the time, but which were eventually not designated.

Lands that are excluded from application for tar sands lease under Alternative 2 described in items 1-4, above, are shown in Figure 2.4.3-1. All prospective tar sands areas are in Utah; the Adobe Town exclusion in Wyoming thus does not affect tar sands areas. The lands that would be available for application for lease under Alternative 2 are shown in Figure 2.4.3-2. Table 2.4.3-1 lists the approximate number of acres of BLM-administered lands, including areas where the federal government owns only the mineral estate, available for application for commercial leasing under Alternative 2 by STSA.[21]

In the formulation of Alternative C in the 2008 OSTS PEIS, the BLM excluded from commercial tar sands development all lands where such surface-disturbance and seasonal limitations were in place to protect known sensitive resources. Lands within each field office where stipulations for no surface disturbance, controlled surface use, or seasonal limitations were in place for oil and gas leasing were also excluded. Table 2.4.3-2 identifies the types of stipulations and restrictions in place for oil and gas leasing in each state that were used to identify lands excluded under Alternative C.

As shown in Figure 2.4.3-1 and reflected in Table 2.4.3-1, 340,181 acres available for application for leasing under Alternative 1 are excluded under Alternative 2; several STSAs become entirely unavailable for application for lease. In addition, in some of the STSAs, a large portion of the lands proposed to be available for leasing is composed of relatively small, isolated tracts of land. These factors could result in limiting the potential amount of commercial tar sands development to a level well below that which might be realized under Alternative 1.

2.4.3.2 Alternative 3, Tar Sands Pending Commercial Lease

This alternative is designed as an analogue to the Research Lands Focus Oil Shale Alternative 3, described in Section 2.3.3.2, in order to respond to scoping comments that called for consideration of closing public lands to all development other than research projects. Unlike with respect to oil shale, there is no specific "RD&D" program for tar sands. Therefore, this alternative would also analyze foregoing the leasing of tar sands for the commercial development of fluid mineral resources, entirely, except for one tar sands lease currently under consideration. The Asphalt Ridge tar sands lease application, shown in Figure 2.4.3-3, is located approximately 11 mi south of Vernal, and the expression of commercial leasing interest that forms its basis was submitted on November 16, 2009. This prospective lease is for a commercial tar sands project; however, as with oil shale, the technology to develop tar sands commercially for fluid minerals development is in its nascent stages. While Alternative 3 analyzes the potential effects of this pending lease application, which covers approximately 2,100 acres, for the purposes of informing land use allocation decision-making, the information and analysis in this PEIS is not considered to be the NEPA analysis sufficient to provide the basis for determining whether or

[21] The maps and acreage estimates were constructed by applying the leasing restrictions discussed in the text to the best available GIS datasets available to the BLM. These maps and acreage estimates may contain errors and should be considered to be only representative of the proposed leasing area for this alternative. As specific areas are considered for commercial leasing, a detailed evaluation of land status would be required.

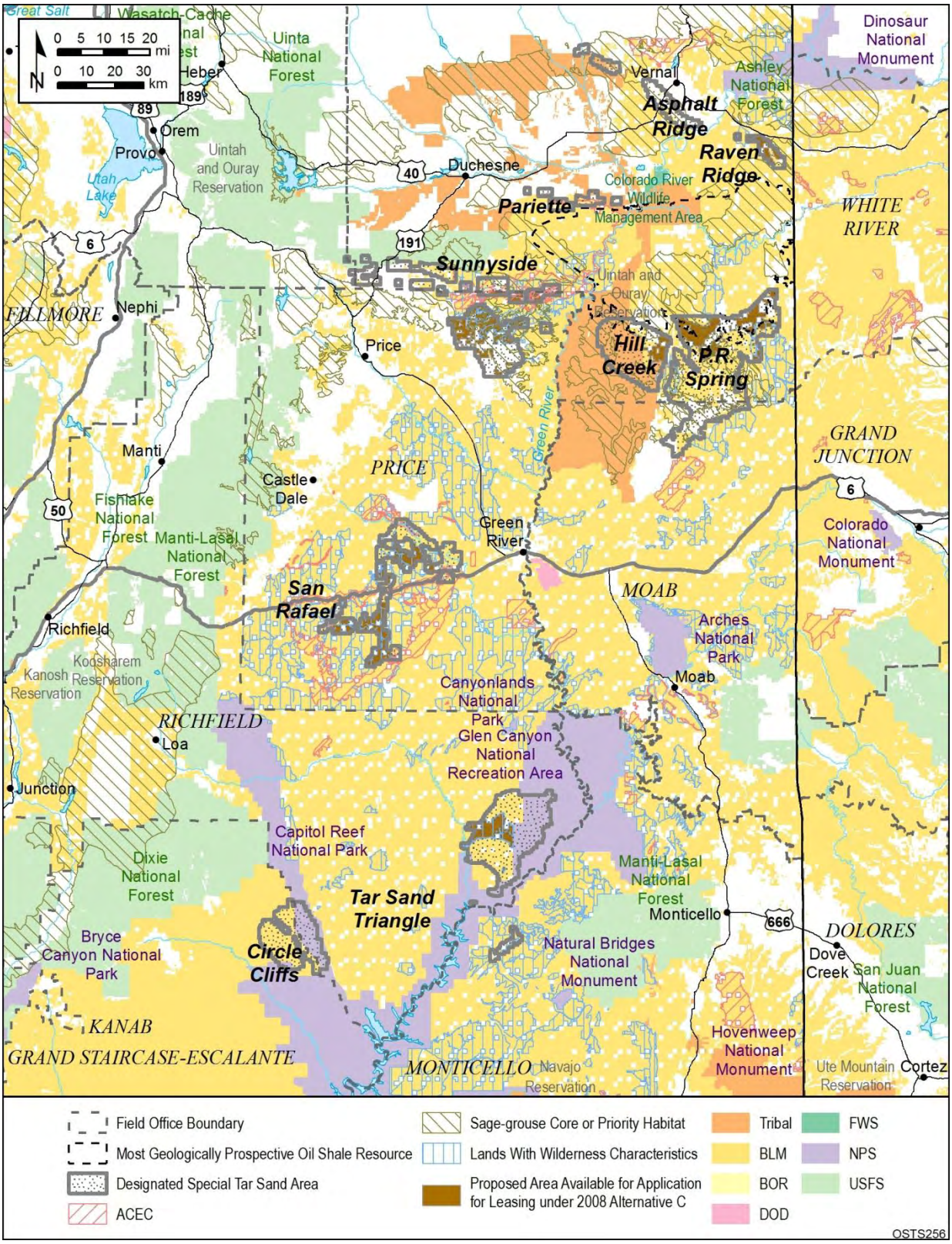

FIGURE 2.4.3-1 Lands Excluded from Application for Leasing under Alternative 2 for Commercial Tar Sands Development within the STSAs in Utah

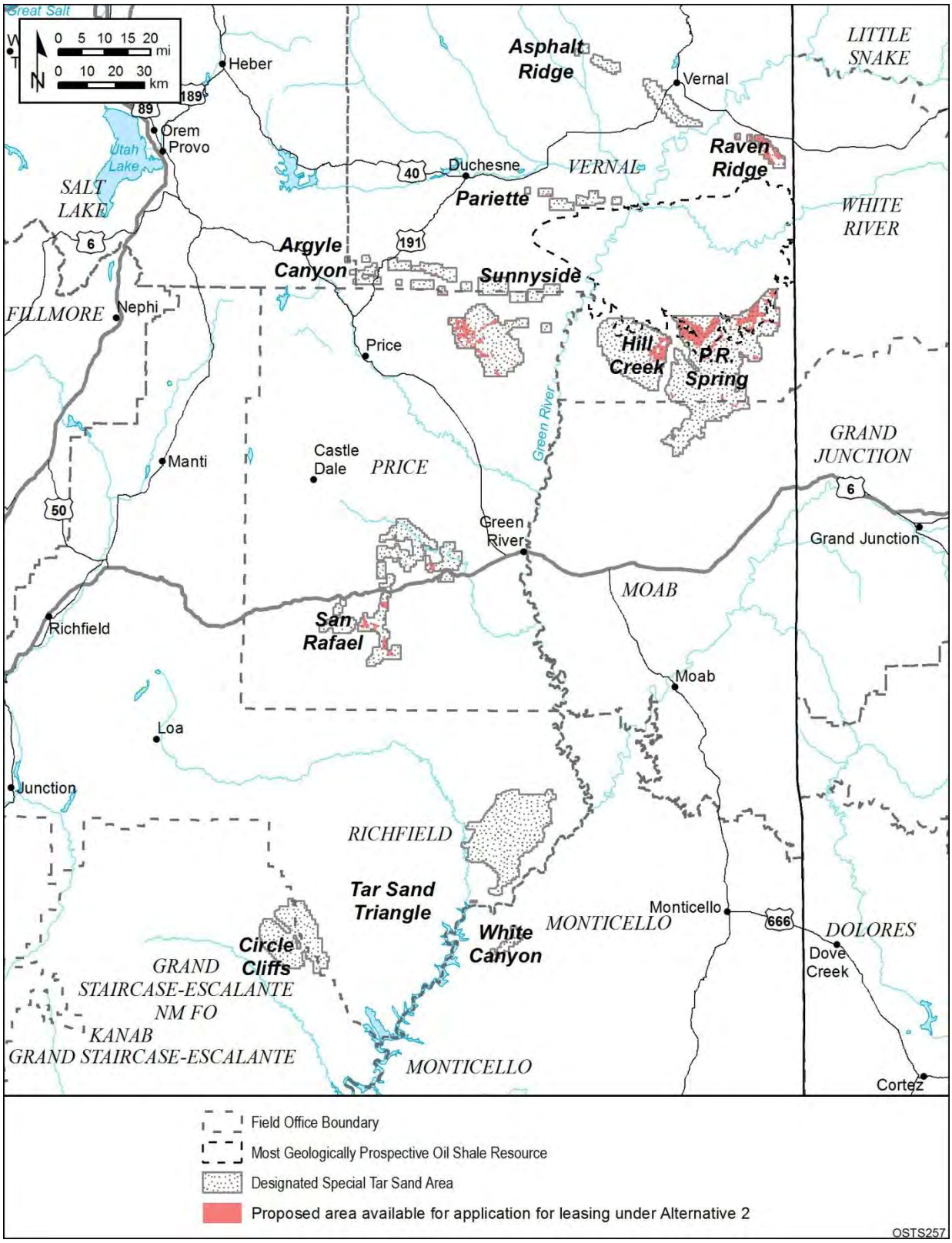

FIGURE 2.4.3-2 Lands Available for Application for Tar Sands Leasing under Alternative 2 for Commercial Tar Sands Development within the STSAs in Utah

TABLE 2.4.3-1 Estimated Acres Potentially Available under Alternative 2 for Application for Leasing in Each STSA for Commercial Tar Sands Development[a]

STSA	BLM-Administered Lands	Split Estate Lands	Total
Argyle Canyon	0	0	0
Asphalt Ridge	0	0	0
Circle Cliffs[b]	0	0	0
Hill Creek	9,355	480	9,835
Pariette	752	78	830
P.R. Spring	38,861	3,443	42,304
Raven Ridge	9,103	16	9,119
San Rafael	8,927	0	8,927
Sunnyside	10,834	9,054	19,888
Tar Sand Triangle	97	0	97
White Canyon	45	0	45
Total for Alternative 2	77,974	13,071	91,045

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS analyses. The GIS data may contain errors; therefore, these estimates should be considered to be only representative of the proposed leasing area.

[b] Leasing for commercial tar sands development in the Circle Cliffs STSA is excluded under all alternatives because it falls entirely within the GSENM and units managed by the NPS on which mineral leasing and development are prohibited.

not to issue that lease. The NEPA analysis associated with the decision whether or not to issue the Asphalt Ridge lease is under preparation in a separate process.

Under this alternative, there is the possibility of limited development, in the event the pending commercial lease is issued; therefore, the opportunity remains for future decisions regarding availability of public lands for this resource to be made on the basis of demonstrable economic viability and in light of specific environmental information. Should tar sands development technologies be demonstrated to be feasible, the opportunity will still exist to consider making public lands available for future development.

2.4.3.3 Alternative 4, Tar Sands Moderate Development (2008 OSTS PEIS ROD Minus Adobe Town and ACECs)

Under Alternative 4, the BLM would amend four land use plans in Utah to designate acreage less than 430,686 acres as available for application for commercial tar sands leasing.

TABLE 2.4.3-2 Resources Covered by Stipulations and Restrictions in Place for Oil and Gas Leasing in the STSAs That Were Used to Identify Lands Not Available for Application for Tar Sands Leasing under Alternative C of the 2008 OSTS PEIS

Slopes and erosive/critical soils
Floodplains, watersheds, and live water
Sage-grouse leks and nesting habitat
Raptor nests and habitat
Wildlife habitat[a]
Special status plants and relict vegetation
VRM Class II areas and other high-quality visual resources
ACECs
Paleontological resources
Other[b]

[a] Wildlife habitat includes a combination of winter range, crucial winter range, summer range, and calving areas for antelope, bighorn sheep, deer, and elk, as well as seclusion areas for other wildlife.

[b] Other resources include SMAs, recreation areas, and areas restricted from leasing for reasons not specified in the GIS data.

This alternative satisfies the settlement agreement to exclude some, but not all, lands from the application of oil shale and tar sands leasing,[22] in comparison to Alternative 2. This alternative would exclude from commercial oil shale or tar sands leasing:

1. The whole of the Adobe Town "Very Rare or Uncommon" area, as designated by the Wyoming Environment Quality Council on April 10, 2008 (180,910 acres total; 167,517 acres of public land, of which 10,920 acres are already a BLM WSA).

2. All ACECs located within the areas analyzed in the 2008 OSTS PEIS (76,666 acres in existing ACECs in the 2008 OSTS PEIS plus additional ACEC acreages as a result of Utah and Wyoming planning efforts recently completed).[23]

Under Alternative 4, lands that would be available for future consideration for leasing would include those BLM-administered lands within the most geologically prospective tar sands areas, including split estate lands where the federal government owns the mineral rights. The

[22] This alternative satisfies the settlement agreement to exclude some, but not all, lands from the application of oil shale and tar sands leasing, in comparison to Alternative 2.

[23] This would only include those ACECs that formally designated in those plans. ACECs that were proposed but not formally designated in the applicable plans undergoing revision/amendment at that time would be excluded.

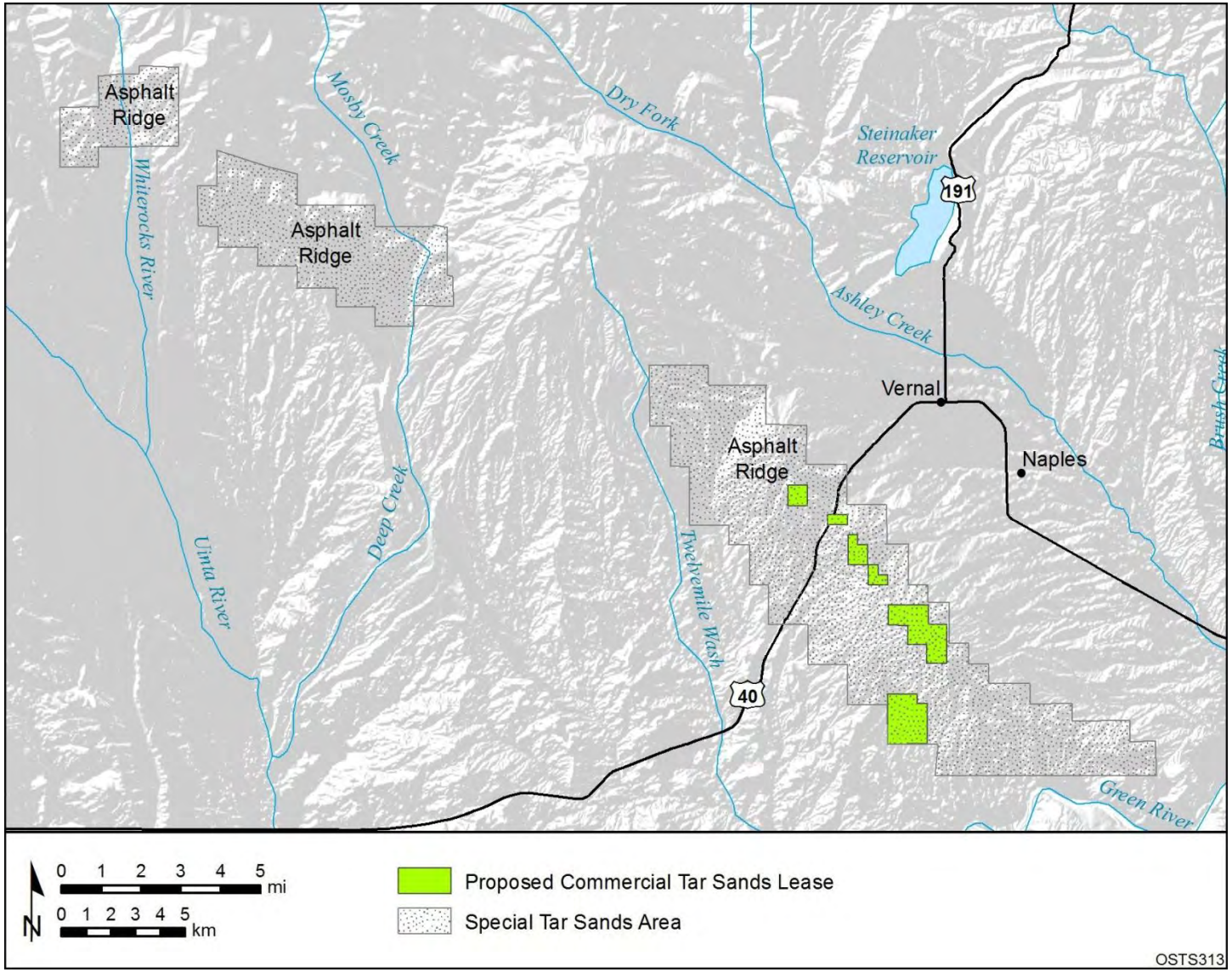

FIGURE 2.4.3-3 Location of Potential Tar Sands Lease under Alternative 3

whole of Adobe Town in Wyoming would be excluded, as would all ACECs, as described above. Lands available for application for tar sands leasing under Alternative 4 are shown in Figure 2.4.3-4.

Lands within the most geologically prospective tar sands areas identified by the BLM as LWC would be managed as in Alternative 1; that is, they would be available for future consideration of leasing and development. Decisions regarding management of these areas would be left to the discretion of the individual field offices to make the leasing decisions, which would determine the management of such areas through additional NEPA and planning processes (as appropriate) with respect to LWC. Thus consideration of management actions for LWC related to oil shale and or tar sands resources would be consistent with what the governing RMP provides with respect to management of such lands for other resources.

Similarly, with respect to the management of sage-grouse habitat, under Alternative 4, lands would be managed as in Alternative 1. No specific decisions regarding core and priority habitat will be made; rather, those decisions will be left up to the individual field offices to make, which would determine the management of such areas through additional NEPA and planning processes (as appropriate) with respect to core and priority sage-grouse habitat consistent with applicable BLM policy. These policies were described in the 2008 OSTS PEIS (pp. 4-78 to 4-80) and include BLM's policies and general practices, including specific frequently used mitigation measures that might be applied to any development, as warranted by analysis at the lease and/or development stage. More recently, the BLM has issued nationwide and state-specific guidance recommending the consideration of certain management practices to address the appropriate management of sage-grouse habitat in the context of land use actions, and this information is presented in a text box in Section 4.8.1 of this PEIS. Field offices would need to take this guidance into account and incorporate protective measures in any authorizations, as warranted by ecological conditions, and on the basis of environmental analysis. As such, it is likely that not all the areas that are currently open under this alternative for potential future leasing would be leased. The maximum acreage developed could be much less than expressed in Table 2.4.3-3, as a result of the application of current BLM policy.

Depending on what the applicable RMP provides with respect to LWC and core and priority sage-grouse habitat, it may be necessary to initiate a plan amendment at the leasing and/or development stage to make allocation decisions on an individual RMP basis regarding management of these lands with respect to oil shale and tar sands resources. The reason for qualifying the amount of acreage available for lease under this alternative is that while areas of core and priority sage-grouse and areas of LWC are left open for potential future leasing and development of oil shale and tar sands resources, the likelihood of all this acreage being available for further oil shale and tar sands resources leasing and development is low. National and state-specific guidance related to sage-grouse management and protection of core and priority habitat will likely result in substantially less acreage being available, as will field office management decisions related to the protection of LWC. It is difficult to establish disturbance amounts at the programmatic level, before more is known regarding the specifics of leasehold location and technology to be used. Tables 2.4.3-4 and 2.4.3-5 show what this might look like under different protective scenarios follow. The scenarios are only provided to illustrate this idea, but the decisions to protect these amounts are not being made at this time as part of this

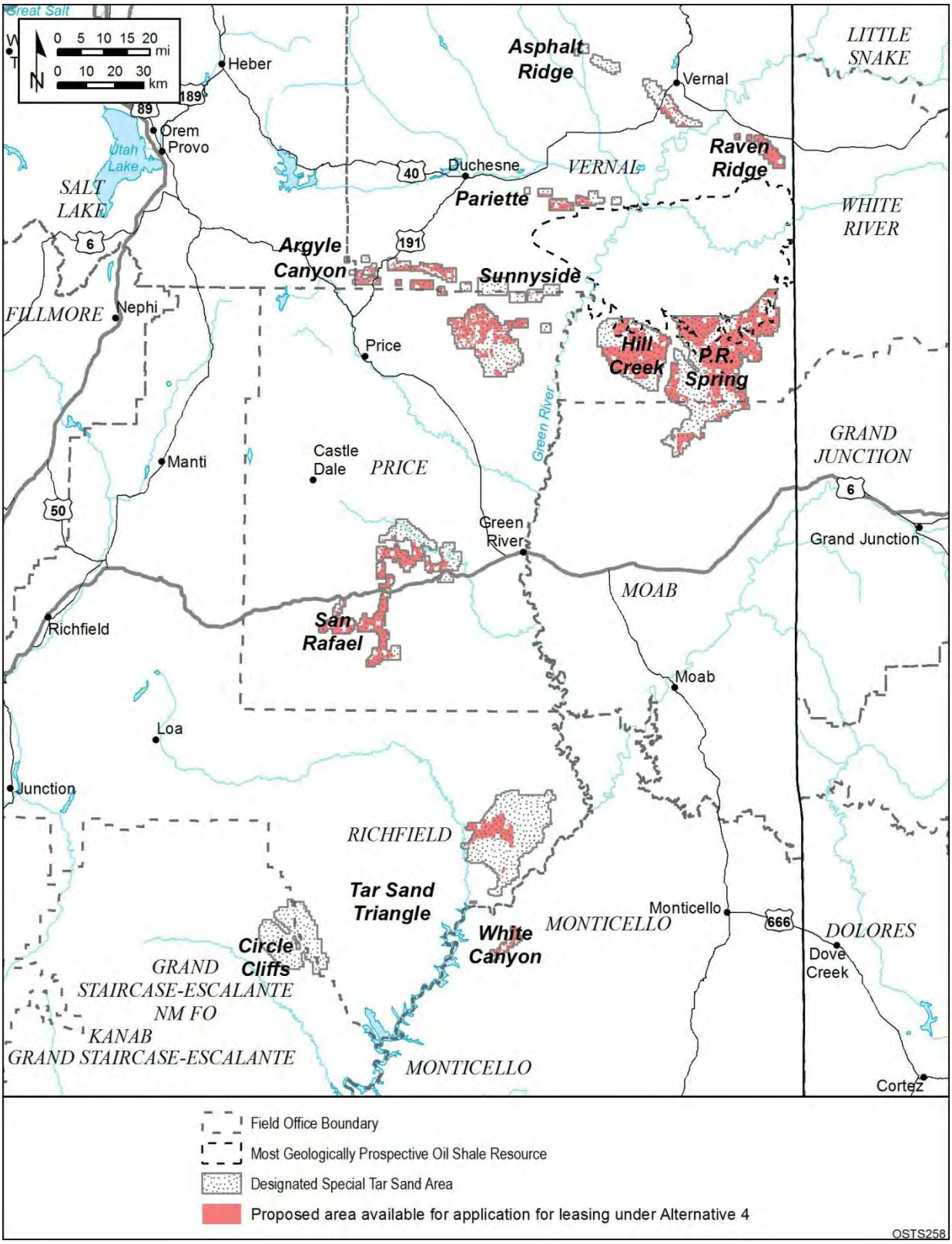

FIGURE 2.4.3-4 Lands Available for Application for Tar Sands Leasing under Alternative 4 for Commercial Tar Sands Development within the STSAs in Utah

TABLE 2.4.3-3 Estimated Acres Potentially Available for Application for Leasing in Each STSA for Commercial Tar Sands Development under Alternative 4[a]

STSA	BLM-Administered Lands	Split Estate Lands	Total
Argyle Canyon	1,022	10,204	11,226
Asphalt Ridge	5,310	125	5,435
Circle Cliffs[b]	0	0	0
Hill Creek	25,568	36,583	62,152
Pariette	10,083	78	10,161
P.R. Spring	145,923	6,694	152,617
Raven Ridge	14,348	16	14,364
San Rafael	69,696	0	69,696
Sunnyside	51,577	16,624	68,200
Tar Sand Triangle	24,938	0	24,938
White Canyon	7,001	0	7,001
Total for Alternative 4	355,466	70,324	425,790

[a] Totals may not be exact because of rounding. These estimates were derived from GIS data compiled for the PEIS analyses. The GIS data may contain errors; therefore, these estimates should be considered to be only representative of the proposed leasing area.

[b] Leasing for commercial tar sands development in the Circle Cliffs STSA is excluded under all alternatives because it falls entirely within the GSENM and units managed by the NPS on which mineral leasing and development are prohibited.

TABLE 2.4.3-4 Estimated Acres Potentially Available in Each State for Application for Leasing for Commercial Tar Sands Development under Alternative 4, Assuming 75% of the LWC and Sage-Grouse Core and Priority Habitat Are Protected through NSO or No Lease Stipulations

State	Acres LWC and Sage-Grouse[a]	BLM-Administered Lands	Split Estate Lands	Total
Utah	198,776	219,053	57,656	276,708

[a] Acreage that is identified as either LWC or sage-grouse core or priority habitat or both within Alternative 4.

TABLE 2.4.3-5 Estimated Acres Potentially Available in Each State for Application for Leasing for Commercial Tar Sands Development under Alternative 4, Assuming 25% of the LWC and Sage-Grouse Core and Priority Habitat Are Protected through NSO or No Lease Stipulations

State	Acres LWC and Sage-Grouse[a]	BLM-Administered Lands	Split Estate Lands	Total
Utah	198,776	309,995	66,101	376,096

[a] Acreage that is identified as either LWC or sage-grouse core or priority habitat or both within Alternative 4.

land use plan amendment initiative. These decisions will be made at the field office level as part of the NEPA and/or planning analyses completed for leasing and site specific development.

2.4.4 Preferred Alternative

At this stage in the planning and NEPA process, the BLM has chosen Alternative 2(b) as the preferred alternative for oil shale, and Alternative 2 as the preferred alternative for tar sands. With respect to oil shale, the BLM would like to maintain focus on RD&D projects, so as to obtain more information about the technological requirements for development of this resource, as well as the environmental implications, before committing to broad-scale commercial development. For instance, the BLM looks forward to gaining a clearer understanding of the implications of development of oil shale for water quality and quantity. Similarly, with respect to tar sands, while there is no formal RD&D program for tar sands, this resource is not, at present, a proven commercially viable energy source, and the BLM would like to obtain more information about the environmental consequences associated with its development, prior to committing to broad-scale commercial development.

The BLM planning regulations at 43 CFR 1610.4-7 require identification of the preferred alternative in a Draft EIS for a land use plan. The identification of a preferred alternative does not constitute a commitment or decision in principle, and there is no requirement to select the preferred alternative in the ROD. The identification of the preferred alternative may change between a draft EIS and a final EIS. Various components of separate alternatives that are analyzed in the draft can also be “mixed and matched” to develop a complete alternative in the final. For example, it has been suggested by one of the cooperating agencies, and seconded by others, that the BLM develop an alternative that would allow for larger scale leasing and development in Utah and Wyoming where the majority of the cooperators support a program that makes more federal oil shale and tar sands resources available for application for future leasing, while limiting development in Colorado where the majority of the cooperators favor a more cautious approach to leasing and development. The BLM seeks comments on this approach as well as other approaches that combine elements of the various alternatives.

2.5 ALTERNATIVES AND ISSUES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

During the initial public comment period regarding the scope of the PEIS, a number of comments were submitted regarding the analysis of specific alternatives or issues. Several suggestions for specific alternatives were incorporated into alternatives assessed in the PEIS.

As discussed below, some of the suggested alternatives and key issues were determined to be either outside the scope of the PEIS or inappropriate to incorporate as recommended in the comment. As a result, these alternatives and issues were eliminated from detailed analysis in the PEIS. The following sections discuss these alternatives and issues, why they were eliminated, and, where applicable, how parts of the PEIS process address the general points raised by commentors.

2.5.1 Alternatives That Use the New USGS In-Place Oil Assessment Maps as the Basis for the Planning Area To Be Analyzed

Several comments were received during the public scoping process that suggested that the BLM should develop an alternative that examines the oil shale resource in the area defined by the recent USGS assessment of in-place oil in oil shales of the Green River Formation in the Piceance and Uinta Basins of western Colorado and eastern Utah (USGS 2010a,b; 2011). Estimated total in-place oil in the Piceance Basin is about 1.5 trillion barrels, or about 50% larger than the previous in-place assessment of about 1 trillion barrels. Almost all of this increase is due to (1) new areas being assessed that had too little data to assess in the previous assessment and (2) new intervals assessed that were not assessed previously. The assessment itself says, “Much of this previously unassessed resource is of low grade and is unlikely to be developed.” The BLM considered this new information and has determined that while the new data should inform and update the 2012 PEIS effort, particularly with respect to information pertaining to the 2008 PEIS study area, the boundaries defining the in-place assessment do not represent the most geologically prospective areas of the Green River Formation located in the Piceance, Uinta, Green River, and Washakie Basins. Therefore, the PEIS will not employ the USGS boundary to define the study area.

2.5.2 Alternatives That Would Apply the Wyoming “Most Geologically Prospective Area” Criteria to Colorado and Utah

Comments were received during the public scoping process that suggested the BLM should develop an alternative that examines the oil shale resource area within an area where the grade and thickness of the oil shale deposits yield 15 gal of oil shale per ton of rock (gal/ton) or more and are 15 ft thick or greater. The PEIS evaluates the potential impacts of designating lands as available or not available for commercial leasing of oil shale and tar sands resources that are located on public lands in Colorado, Utah, and Wyoming. Specifically, the study area for the oil shale resources includes the most geologically prospective resources of the Green River Formation located in the Piceance, Uinta, Green River, and Washakie Basins. The BLM is

continuing to employ for this planning initiative the standard it developed pursuant to the Energy Policy Act of 2005, which is to focus on the most geologically prospective resources as defined by grade and thickness of the deposits.

For the purposes of this PEIS, the most geologically prospective oil shale resources in Colorado and Utah are those deposits that yield 25 gal/ton or more of oil shale and are 25 ft thick or greater. In Wyoming, where the oil shale resource is not of as high a quality as it is in Colorado and Utah, the most geologically prospective oil shale resources are those deposits that yield 15 gal/ton or more of oil shale and are 15 ft thick or greater. The BLM has determined that it would not make economic sense to open larger areas in Colorado and Utah to potential oil shale leasing where the resource is of low grade and unlikely to be developed at this time, because interest in future leasing would be directed at higher grade deposits. Future oil shale production will depend on technological progress and on the levels and volatility of future oil prices. Technology progress will determine how quickly the costs of oil shale extraction can be brought down and how economically natural gas and petroleum liquids can be produced from the process. In the future, once technology has progressed and the higher quality oil shale has been leased and developed, it may be economic to produce these lower-grade deposits. At that time, additional planning and NEPA analysis could be conducted to open these areas to leasing and development, where warranted. If, however, technological progress and economic conditions rapidly come to support development of deposits less than 25 ft thick and yielding less than 25 gal/ton, the areas that would be open in Wyoming under Alternative 1, 2, or 4 would be available for future leasing without further land use planning amendments.

2.5.3 Alternatives Considering Alternate Energy Sources and Carbon Sequestration

Several comments were received during public scoping that suggested that the BLM should evaluate the development of alternate energy sources, including renewable energy (e.g., wind and solar power systems), nuclear energy, and conventional oil and gas resources instead of or in comparison with the development of oil shale or tar sands. In addition, several comments suggested that the BLM should evaluate ways to displace the nation's dependence on oil through conservation and market- and innovation-based strategies. The BLM has determined that such evaluations, although worthwhile with respect to national energy policy development, do not fulfill the purpose of the proposed action to be analyzed in the PEIS, which is to establish an appropriate mix of public lands as open or closed to commercial oil shale and tar sands development.

In addition, several comments suggested that the BLM should evaluate oil shale and tar sands technologies that incorporate carbon sequestration. While the PEIS may acknowledge that such technologies may become available for use, the BLM believes this is an issue that would be best examined in detail at the time of site-specific NEPA analyses of a specific plan of development.

2.5.4 Alternatives That Prohibit Leasing in Specific Areas

A number of scoping comments requested that the BLM develop alternatives prohibiting commercial leasing in specific areas, including all NPS units, the GSENM, existing WSAs, and wilderness-quality lands in Utah. Since the scoping meetings were conducted, the BLM has determined that the scope of this PEIS will be limited to BLM-administered lands only and will not evaluate commercial leasing on USFS- and NPS-administered lands.

Wilderness Areas, WSAs, other lands within the NLCS (including National Monuments), and existing ACECs currently closed to mineral development are excluded from consideration for leasing under all alternatives in the PEIS.

2.5.5 Off-Site Processing of Oil Shale

At least one comment suggested that the BLM develop an alternative that examines off-site processing of oil shale in locations where environmental impacts may be mitigated by site-specific factors. Constructing adequate scenarios that could evaluate all the possible locations and site-specific factors contributing to the magnitude (or mitigation) of impacts would be speculative and potentially misleading. Such considerations might be appropriate at the site-specific level when more information is known about the project location, specific technologies, and other factors. Potential mitigation could be incorporated into the project plan of development at that time.

2.5.6 Establishment of Federal Subsidies

Several comments suggested that the BLM evaluate the potential for federal subsidies and the level of subsidy required to facilitate leasing and development. This suggestion was considered to be outside the scope of the PEIS, which provides analysis related to a purpose and need focused on land use planning decision-making.

2.5.7 Closing of All RD&D Lease Lands, Except for Three Pending Oil Shale RD&D Applications and One Pending Tar Sands RD&D Lease in the Vernal Field Office

One comment suggested closing all RD&D lease lands, except for three pending oil shale RD&D applications and one pending tar sands RD&D lease in the Vernal Field Office. This would mean that the existing RD&D leases, if relinquished, could not be leased again, without another planning process. This alternative was not carried forward because it is largely similar to Alternative 3 and is not consistent with the Secretary's and the Director's emphasis on developing and maintaining a robust RD&D process.

2.5.8 Opening of All ACECs to Oil Shale Leasing

The BLM also considered whether it would be appropriate to include an alternative that opened all ACECs to oil shale and tar sands leasing. This suggestion was not carried forward because a blanket opening of all ACECs to oil shale and tar sands development is not reasonable where some ACECs are closed to fluid mineral development, because of the very specific resource concerns that support their designation as ACECs. It is anticipated that development of oil shale and tar sands resources is likely to have at least as many, if not more impacts on resources as conventional fluid minerals development.

2.5.9 Opening of All Lands with Wilderness Characteristics to Oil Shale and Tar Sands Leasing

At least one comment suggested that the BLM develop an alternative that directs that the LWC remain open to oil shale and tar sands leasing, without restrictions, and without allowing, as is allowed in the no action alternative, individual field offices to exercise their discretion as to how to manage these lands. Under the no action alternative and Oil Shale and Tar Sands Alternatives 4 (Moderate Development), the BLM has not explicitly excluded leasing within lands it believes may have wilderness characteristics, as it has under e Alternatives 2 and 3 for each resource. Recently completed and ongoing plan revisions and plan amendments in many of the field offices where such lands have been identified will determine appropriate management requirements for these areas, under the No Action Alternative and the Moderate Development Alternative for each resource. These management prescriptions may provide for limitations on uses that may take place in areas determined to have wilderness characteristics. Oil shale or tar sands development in such areas may prove inconsistent with such management prescriptions adopted for those areas. Such development may also be inconsistent with the Secretary's and Director's emphasis on developing and maintaining a robust RD&D process in order to discern more about developing technologies before committing certain kinds of resource areas to such uses.

2.5.10 Mid-Range Alternative That Excludes a Fixed Percentage of Lands with Wilderness Characteristics

In an effort to include as part of the analysis, an alternative that considered a moderate approach to management of both LWC and development of oil shale and tar sands resources, the BLM considered including as an element of Alternative 4, above, a provision that would exclude from surface disturbance that may result from oil shale or tar sands development, a fixed percentage of lands identified as having wilderness characteristics, calculated either on a per leasehold basis, or on the basis of the total LWC identified, regardless of leasehold boundary.

The BLM considered several possibilities as to how to structure such a provision, in order to display for purposes of analysis, what such a moderate approach would look like. For instance, the BLM considered whether the percentage disturbance should be calculated on a per leasehold basis or on the basis of the total acreage of the lands identified as having wilderness characteristics, regardless of leasehold boundary. Either option would provide the BLM with a

flexible approach to managing LWC and mitigating potential impacts, depending on project location and technology proposed for use. The primary difference between these two structural possibilities was that, while the latter would seem to offer the BLM more flexibility in preserving the wilderness characteristics, its drawback would be that it would allow the first lessee to "monopolize" the available disturbance percentage of LWC, depending on the relative configuration of lease boundaries and LWC.

Similarly, the BLM considered what the appropriate disturbance percentage might be in order to structure a moderate approach, at this land use allocation stage, but determined that it was not possible to identify a specific percentage, unless specific information was known regarding the relative configuration of the particular proposed leasehold and the potentially impacted LWC, as well as information about the technology to be used and the specifics regarding potential reclamation.

In examining these options, it became clear that such an alternative would be difficult to represent at all, as well as analyze in detail, given the lack of availability of this specific information. Further, the BLM determined that the impacts of such a moderate approach were already considered in the range of alternatives undergoing detailed analysis. That is, under the Conservation Focus and the Research Lands Focus Alternatives, LWC would be identified as not available for future consideration of commercial oil shale and tar sands leasing and development. However, under the No Action and Moderate Development Alternatives, the LWC are to remain available for future consideration of oil shale and tar sands leasing, where such future consideration would be carried out consistent with the manner in which the applicable individual RMP provides for management of wilderness characteristics, when further specifics about proposed commercial leasing and development projects would be known. In the No Action and Moderate Development Alternatives, in particular, the impact analysis displays in a qualitative manner the potential environmental consequences of such commercial leasing and development on LWC. Under the No Action and the Moderate Development Alternatives, specific impacts on LWC would be analyzed in future NEPA analysis supporting individual lease decisions and particular project designs.

At the leasing stage, the field offices may consider maximum disturbance limits and other mitigation measures for the management of oil shale within LWC.

2.5.11 Carrying-Capacity Thresholds

A number of commentors suggested that the BLM consider the potential impacts of oil shale development within the context of carrying capacity of the regional and local environment and communities. The carrying capacity of a system is the maximum level of activity that can be sustained within a specific area without significant, detrimental impact. The White River RMP (BLM 1997b) established carrying-capacity thresholds specific to oil shale development and potential impacts on air quality, socioeconomic impacts, big game habitat, and water quality. Carrying-capacity thresholds have not been established elsewhere within the three-state study area. Although the programmatic alternatives do not explicitly consider carrying-capacity thresholds nor propose that commercial levels be constrained in the future by these thresholds, they do require that additional site-specific NEPA analyses be conducted prior to the issuance of

commercial leases. At that time, when complete information is available defining the location of the commercial development, technologies to be employed, scale of operations, and time line for development, analyses can more reliably define appropriate carrying-capacity thresholds and evaluate potential impacts.

2.5.12 Establishment of Trust Funds

Several commentors requested the PEIS consider the establishment of a trust fund to provide financial support to local communities early in the development process. While the PEIS socioeconomic impact analyses consider the potential benefits of a trust fund in terms of impact mitigation, requiring lessees to establish such a fund is beyond the jurisdiction of the BLM and, therefore, is not included in any of the alternatives. If an applicant proposes such a fund as part of its plan of development, perhaps as potential mitigation for socioeconomic impacts, the BLM would analyze it in site-specific NEPA analyses of the plan of development.

2.5.13 Research Lands Focus That Considers Only the Current RD&D Leases

Under all of the allocation alternatives, the six RD&D leases that have been issued contain terms that allow development of the original leases and could allow development of the associated PRLAs, totaling 30,720 acres. Three pending RD&D oil shale leases are under review, with smaller PRLA acreage totaling 1,920 acres. For purposes of analysis, it is assumed in all alternatives that each of these pending RD&D leases could reach commercial production utilizing the technologies being tested on the leases and may utilize the whole PRLA area. One pending tar sands application, with acreage totaling 2,100 acres is also currently under review. Recognizing that there is a chance that one or more of these pending RD&D oil shale leases and/or the pending tar sands lease would not be approved, the BLM considered developing a separate subalternative under each alternative to analyze these differences. However, since this PEIS is necessarily a qualitative PEIS, it was determined that because of the minimal acreage under consideration, these subalternatives would not be substantially different from the three action alternatives. Impacts from excluding the three new RD&D oil shale projects and/or the pending tar sands lease would be qualitatively similar but smaller in scale than those discussed in the three action alternatives.

2.6 COMPARISON OF ALTERNATIVES

The alternatives presented in this PEIS were evaluated for potential environmental impacts associated with the amendment of land use plans to identify BLM-administered lands in Colorado, Utah, and Wyoming that would be made available or not available for application for leasing for commercial oil shale or tar sands development. The PEIS also identifies the types of environmental impacts that could accompany commercial oil shale and tar sands development. More quantitative and detailed impact analyses, including the identification of the magnitude and extent of potential impacts on specific social, cultural, economic, and natural resources, will be conducted at the leasing and project levels. Table 2.6-1 summarizes the impacts of oil shale alternatives, and Table 2.6-2 summarizes the impacts of the tar sands alternatives that are more fully described in Chapter 6 of the PEIS.

TABLE 2.6-1 Summary Comparison of Potential Environmental Impacts of Amending Land Use Plans To Identify Lands Available or Not Available for Application for Leasing for the Commercial Development of Oil Shale, Including RD&D, in Colorado, Utah, and Wyoming, and Environmental Impacts of Future Construction and Operation of Commercial Projects under the Four Alternatives

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Impacts Common To All Alternatives	The six existing 160-acre RD&D projects are valid existing rights, and the impacts are the same for each of the alternatives. Each of the existing RD&D projects may be expanded to include a total of 5,120 acres if the terms and conditions of their existing leases are met. Commercial development could occur on a total acreage of 30,720 acres based on these existing leases. Impacts identified under Alternative 3 for the RD&D leases would be the same as those under Alternatives 1, 2, and 4. On the basis of the analysis in this PEIS, the BLM has determined that, with the exception noted in the socioeconomic analysis regarding potential impacts on property values, land use plan amendments under Alternatives 2, 3, and 4 would not result in any impacts on the environment or socioeconomic setting. However, the future development of commercial oil shale projects that could be approved after subsequent NEPA analysis identified in these three alternatives would have impacts on these resources. The types of impacts that could be associated with future commercial oil shale development are described in Chapter 4 of the PEIS. The magnitude of these potential impacts cannot be quantified at this time because key information about the location of commercial projects, the technologies that may be employed, the project size or production level, development time lines, and mitigation measures that would be applied, are unknown.			

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Land Use	Current land uses such as grazing, irrigated agriculture, recreation, oil and gas production, and mineral extraction would be affected at locations where commercial oil shale projects (and supporting infrastructure) would be located within the current 2,017,714-acre lease area. These lands include 12 ACECs totaling 46,000 acres where oil and gas leasing is allowed. Additional land use changes would occur on nonfederal lands where project support infrastructure (e.g., power plants and employer-provided housing) would be constructed.	Potential impacts of commercial development would be similar in nature to the impacts identified for commercial development under Alternative 1, but Alternative 2 would make available for application for leasing only 461,965 acres and thus would have less impact on such land uses overall, especially in the Piceance Basin. Alternative 2 would exclude all lands containing core and priority sage-grouse habitat and LWC. Additional land use changes would occur on nonfederal lands where project support infrastructure (e.g., power plants and employer-provided housing) would be constructed.	RD&D project development and operations on up to 32,640 acres would have effects on land use similar in nature to those for Alternative 1 but on a far smaller land area. The RD&D projects are not expected to affect land use on adjacent parcels except where vehicular traffic, noise, and construction and operations activities could alter the quality of recreational activities. Additional land use changes would occur on nonfederal lands where project support infrastructure (e.g., power plants and employer-provided housing) would be constructed.	The effects of Alternative 4 on current land uses such as grazing, irrigated agriculture, recreation, oil and gas production, and mineral extraction within the 1,963,414-acre proposed lease area would be similar in nature and magnitude to those for Alterative 1. However, Alternative 4 would exclude leasing on 12 ACECs totaling 46,000 acres and within about 10,000 acres of the Adobe Town area in Wyoming. Additional land use changes would occur on nonfederal lands where project support infrastructure (e.g., power plants and employer-provided housing) would be constructed.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Soil and Geologic Resources	Future commercial oil shale development could affect soil and geologic resources in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Potential impacts would be associated with the construction and operation of project facilities and related infrastructure and would include soil disturbance, soil removal and compaction, subsurface disturbance of geologic resources during drilling and mining, and increased erosion potential of exposed soils and geologic materials.	Potential project impacts from future project development would be similar to those identified for Alternative 1 but could occur at fewer locations and in less geologically sensitive locations.	Geologic resources could be affected by construction and operation activities at the six existing and three proposed 160-acre RD&D locations and at areas where support infrastructure (e.g., utility ROWs and access roads) would be located. Potential impacts on soil and geologic resources from development of the RD&D sites would be similar to those identified for Alternatives 1 and 2, but under Alternative 3 impacts would be limited geographically and in overall magnitude.	Similar to Alternative 1.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Paleontological Resources	Impacts could include the destruction of paleontological resources and loss of valuable scientific information within development footprints, degradation and/or destruction of resources and their stratigraphic context within or near the development area, and increased potential for loss of exposed resources from looting or vandalism as a result of increased human access and related disturbance in sensitive areas. Such impacts could be reduced or eliminated by applying mitigation measures; therefore, adverse impacts are not expected. About 90% of designated acreage (1,784,773 acres) overlies geologic formations having a high potential to contain important paleontological resources	The types of potential impacts would be similar to those identified under Alternative 1. Such impacts could be reduced or eliminated by applying mitigation measures; therefore, adverse impacts are not expected. About 95% (441,120 acres) of designated acreage overlies geologic formations having a high potential to contain important paleontological resources (i.e., PFYC 4/5). Most of the available acreage overlying high potential geologic formations occurs in Utah (232,239 acres).	The types of potential impacts would be similar to those identified under Alternative 1. Such impacts could be reduced or eliminated by applying mitigation measures; therefore, adverse impacts are not expected. All the existing RD&D lease areas overly geologic formations having a high potential to contain important paleontological resources (i.e., PFYC 4/5). Of the new acreage designated (1,920 acres), about 76% (1,456 acres) overlies geologic formations having a high potential to contain important paleontological resources. Most of these are located in the Piceance Basin, Colorado (1,121 acres).	The types of potential impacts would be similar to those identified under Alternative 1. Such impacts could be reduced or eliminated by applying mitigation measures; therefore, adverse impacts are not expected. About 92% (1,769,266 acres) of designated acreage overlies geologic formations having a high potential to contain important paleontological resources (i.e., PFYC 4/5). Most of the available acreage overlying high potential geologic formations occurs in Wyoming (857,040 acres).

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Paleontological Resources (Cont.)	(i.e., PFYC 4/5). Most of the available acreage overlying high potential geologic formations occurs in Wyoming (857,040 acres).			
Water Resources	Commercial oil shale development could impact water resources in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. In the geologically prospective oil shale areas (including a 2-mi buffer zone) are about 184 mi of perennial streams in the Piceance Basin (or about 92% of the total perennial streams in the basin), about 262 mi of perennial streams in the Uinta Basin (or 100% of the total perennial streams in the basin), 190 mi of perennial streams in	Potential impacts from future construction and operation of commercial oil shale projects would be similar to those identified for Alternative 1 but could occur at fewer locations and in less geologically sensitive locations. Alternative 2 includes a total of 386 mi of perennial streams that could be affected by commercial project development, or 51% of the total perennial streams in the four basins. In addition, Alternative 2 excludes lands that are currently identified in BLM land use plans as having steep slopes and/or fragile or highly erosive soils included in Alternative 1. Thus, there is a	Water resources could incur localized impacts as a result of construction and operation activities of the six existing and three proposed RD&D projects. Surface disturbance at the sites could lead to increased erosion and subsequent runoff and sedimentation to local streams. A total of 28 mi of perennial streams could be affected by RD&D, amounting to 12% of the total perennial streams in Colorado and 2% of those in Utah. Groundwater could be affected by dewatering or contamination due to accidental releases of hazardous materials and by-products of retorting	Similar to Alternative 1.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Water Resources (Cont.)	the Green River Basin (or 75% of the total streams in the Basin), and 39 mi of perennial streams in the Washakie Basin (or 75% of the total streams in the Basin). Altogether, the quantity of stream miles is 674 mi, or about 90% of the miles of perennial streams in the four basins. Potential project-related impacts may include reduced surface water quality due to erosion and sedimentation, dewatering of local aquifers, modification of surface and groundwater flow, and contamination of surface water or groundwater due to accidental releases of hazardous materials and by-products of retorting.	reduced potential for erosion-related impacts with commercial oil shale development under this alternative.		

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Air Quality	Commercial oil shale development could impact air quality in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants or transmission lines) would be located. The construction and operation of future commercial oil shale projects could result in local and regional impacts on air quality and AQRVs, such as visibility and acid deposition. These impacts could result from heavy equipment and vehicle emissions, fugitive dust generation from construction and mining areas and along some access roads, and oil shale processing emissions. In addition, O_3 precursors of NO_x and VOCs from oil shale development could exacerbate wintertime high-O_3 occurrences already prevalent in the study area.	Commercial oil shale development could impact air quality in the Alternative 2 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants or transmission lines) would be located. Potential local and regional impacts on air quality and AQRVs would be similar in nature to those identified for Alternative 1. However, Alternative 2 has more than 1.5 million fewer (about 77%) acres of land than Alternative 1 where future commercial oil shale development could occur and affect local or regional air quality and AQRVs. And, thus, the magnitude of potential impacts is anticipated to be far less than that for Alternative 1.	Air quality is not expected to be adversely affected by the construction and operation of the six current and three proposed RD&D projects. Minor, localized impacts could result from heavy equipment and vehicle emissions, fugitive dust generation from construction and mining areas and along some access roads, and oil shale processing emissions. Commercial oil shale development could impact air quality in the Alternative 3 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants or transmission lines) would be located. Potential local and regional impacts on air quality and AQRVs would be similar in nature to those identified for Alternative 1. However, because of its far smaller lease	Commercial oil shale development could impact air quality in the Alternative 4 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants or transmission lines) would be located. Potential local and regional impacts on air quality and AQRVs would be similar in nature and magnitude to those identified for Alternative 1. Alternative 4 has only approximately 62,500 fewer (about 3%) acres of land than Alternative 1 where future commercial oil shale development could occur and affect local or regional air quality and AQRVs.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Air Quality (Cont.)	Because of the need for project- and site-specific information, it is not possible to identify the nature and magnitude of regional air quality impacts from commercial development within the Alternative 1 potential lease areas.		areas (about 1.7% of land for Alternative 1), the magnitude of potential impacts is anticipated to be minimal compared to that for Alternative 1.	
Noise	Commercial oil shale development could affect noise levels in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants or transmission lines) would be located. In most cases, noise is considered a local problem, not a regional problem. Localized noise levels (i.e., increased noise levels) could be affected by construction activities,	Commercial oil shale development could impact noise levels in the Alternative 2 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants or transmission lines) would be located. Localized noise impacts would be similar in nature and magnitude than those identified for Alternative 1. Changes in ambient noise levels due to project development could	Localized noise impacts (i.e., increased noise levels) could occur at each of the RD&D project locations as a result of construction activities, mining, operating machinery (e.g., crushers and conveyors) and other equipment (generators and compressors), and vehicular traffic. Commercial oil shale development could affect noise levels in the Alternative 3 potential lease areas and at locations on nonfederal lands	Commercial oil shale development could affect noise levels in the Alternative 4 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants or transmission lines) would be located. Localized noise impacts would be similar in nature and magnitude than those identified for Alternative 1. Changes in ambient noise levels due to project development could

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Noise (Cont.)	mining, processing equipment (e.g., crushers and conveyors), pipeline compressor stations, and vehicle traffic. Noise levels from oil shale development could exceed EPA guidelines and/or Colorado regulations for receptors in close proximity but would not exceed them at farther receptor locations (e.g., beyond 0.5 mi).	occur wherever a project is located within the 461,965 acres identified as available for application for leasing under Alternative 2, which is about 1.5 million fewer (about 77%) acres of land than under Alternative 1.	where project-related infrastructure (e.g., power plants and transmission lines) would be located. Localized noise impacts would be similar in nature and magnitude than those identified for Alternative 1. Changes in ambient noise levels due to project development could occur wherever a project is located within the 32,640 acres identified as available for application for leasing under Alternative 3, which is only about 1.7% of the land under Alternative 1.	occur wherever a project is located within more than 1.9 million acres identified as available for application for leasing under Alternative 2, which is about 62,500 fewer (about 3%) acres of land than under Alternative 1.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Ecological Resources (resource subgroups summarized below)	Ecological resources could be affected at each of the proposed areas available for application for leasing of oil shale resources. Impacts related to oil shale development may include wildlife disturbance, habitat loss, exposure to accidental releases of hazardous materials, the spread or establishment of invasive species, and the loss or injury of biota within physically disturbed areas related to the projects (e.g., utility ROWs and access roads).	Commercial oil shale development could impact ecological resources in Alternative 2 potential lease areas in the same manner as Alternative 1 but on 1.5 million fewer acres, some of which has been excluded because of the presence of sensitive ecological resources.	Commercial oil shale development within the Alternative 3 potential lease areas could adversely affect ecological resources in these areas in the same manner as in Alternative 1 but would occur on 1.9 million fewer acres of land.	Commercial oil shale development within the Alternative 4 potential lease areas could adversely affect ecological resources in these areas in the same manner as in Alternative 1 but would occur on 62,450 fewer acres of land.
	Indirect impacts such as those related to surface and groundwater withdrawals could occur in more distant but hydrologically connected areas.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Aquatic Resources	For Alternative 1, within the lease areas (including a 2-mi buffer), there are 49 perennial streams totaling 674 mi. The construction and operation of commercial oil shale projects within the lease areas could adversely affect aquatic resources in these streams. Aquatic resources could be affected by changes in water quality due to erosion, runoff, recharge by contaminated groundwater, and accidental releases of hazardous materials from the project areas. Surface water depletion resulting from groundwater and surface water use could negatively affect aquatic resources. Some aquatic biota could be impacted as a result of the physical disturbance of aquatic habitats during construction and by utility and ROW crossings. Project-related ROWs could also increase public access to aquatic habitats.	For Alternative 2, within the lease areas (including a 2-mi buffer), there are 37 perennial streams totaling 386 mi. The construction and operation of commercial oil shale projects within the lease areas could adversely affect aquatic resources in these streams. Potential types of impacts would be similar to those identified for Alternative 1 and could result in habitat loss or degradation, which could affect the abundance and distribution of aquatic biota in the affected habitats.	For Alternative 3, within the lease areas (including a 2-mi buffer), there are 7 perennial streams totaling 28 mi. Potential impacts would be similar in nature to those identified for Alternative 1 but could occur in fewer locations.	For Alternative 4, within the lease areas (including a 2-mi buffer), there are 49 perennial streams totaling 662 mi. Potential types of impacts would be similar to those identified for Alternative 1 and could result in habitat loss or degradation, which could affect the abundance and distribution of aquatic biota in the affected habitats.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Plant Communities and Habitats	The construction and operation of commercial oil shale projects could impact plant communities and habitats that are present in the Alternative 1 potential lease areas, including oil shale endemics on or near project sites and in areas where associated infrastructure would be located. Impacts could include the direct loss of vegetation from site clearing and grading; reduced habitat quality due to soil compaction, dewatering, water quality reduction, erosion, sedimentation, or accidental releases of hazardous materials; and the introduction or spread of invasive species. Utility and access road ROWs could also result in the fragmentation of some habitats. These potential lease areas include about 167,800 acres that have been identified for the protection of wetlands, riparian habitats, floodplains, special status and	The construction and operation of commercial oil shale projects could impact plant communities and habitats that occur in the Alternative 2 potential lease areas. These potential lease areas do not include land currently identified for the protection of wetlands, riparian habitats, floodplains, special status or sensitive plant species, or remnant vegetation associations. Potential impacts would be similar in nature to those identified for Alternative 1 but could occur in fewer locations. Alternative 2 areas do not include ACECs but are adjacent to or near 20 ACECs designated for sensitive plants or plant communities.	The construction and operation of commercial oil shale projects in areas available for application for leasing under Alternative 3 could affect plant communities and habitats. The areas available for application for leasing include about 39 acres that have been identified for the protection of sensitive plants and remnant vegetation associations and floodplains. Alternative 3 areas do not include ACECs but are near 3 ACECs designated for sensitive plants or plant communities.	The construction and operation of commercial oil shale projects could impact plant communities and habitats that occur in the Alternative 4 potential lease areas. These potential lease areas include about 146,677 acres of land that have been identified for the protection of wetlands, riparian habitats, floodplains, special status and sensitive plant species, and remnant vegetation associations. Potential impacts would be similar in nature to those identified for Alternative 1 but could occur in fewer locations. Alternative 4 areas do not include ACECs but are adjacent to or near 21 ACECs designated for sensitive plants or plant communities.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Plant Communities and Habitats (Cont.)	sensitive plant species, and remnant vegetation associations. Alternative 1 areas also include all or portions of 8 ACECs and are adjacent to or near 14 ACECs designated for sensitive plants or plant communities.			
Wildlife	The construction and operation of commercial oil shale projects could impact wildlife and their habitats where individual projects are located within the 2,017,714 acres currently classified as available for application for oil shale leasing. Wildlife habitats identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas include, but are not limited to, 106,092 acres of raptor nests, 89,310 acres of big game severe winter range, 136,991 acres of elk crucial winter range, 13,493 acres of elk calving, 163,100 acres of elk	The construction and operation of commercial oil shale projects could impact wildlife and their habitats where individual projects are located within the 461,965 acres identified for oil shale leasing. There were no habitats for wildlife identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas. A total of 112,851 acres of wild horse HMAs, 172,339 acres of mule deer winter habitat, 11,470 acres of mule deer summer habitat, 159,205 acres of elk winter habitat, and	The construction and operation of commercial oil shale projects could impact wildlife and their habitats where individual projects are located within the 32,640 acres identified for oil shale leasing. Wildlife habitats identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas include 78 acres of big game severe winter range and 483 acres of elk and mule deer summer range (these acreages are not additive as they do not account for overlap among habitat categories).	The construction and operation of commercial oil shale projects could impact wildlife and their habitats where individual projects are located within the 1,963,414 acres identified for oil shale leasing. Wildlife habitats identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas include, but are not limited to, 103,719 acres of raptor nests, 83,134 acres of big game severe winter range, 126,828 acres of elk crucial winter range, 12,092 acres of elk calving, 162,099 acres of elk and mule deer summer range,

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Wildlife (Cont.)	and mule deer summer range, 110,671 acres of mule deer crucial winter range, 83,237 acres of mule deer winter range, 29,334 acres of mule deer fawning area, 5,021 acres of mule deer migration corridor, 11 acres of moose winter range, 10,600 acres of pronghorn crucial winter range, and 241,673 acres of pronghorn winter range (these acreages are not additive as they do not account for habitat overlap among species or habitat types for a species). A total of 657,256 acres of wild horse and burro HMAs, 861,159 acres of mule deer winter habitat, 172,773 acres of mule deer summer habitat, 850,442 acres of elk winter habitat, and 172,542 acres of elk summer habitat overlap lands that would be available for oil shale leasing.	11,465 acres of elk summer habitat overlap lands that would be available for oil shale leasing. Overall, potential impacts on wildlife and their habitats would be similar in nature to those identified for Alternative 1, but oil shale leasing could occur in less than 24% of lands identified for Alternative 1.	Only 328 acres of wild HMAs, 1,456 acres of mule deer winter habitat, 483 acres of mule deer summer habitat, 1,456 acres of elk winter habitat, and 483 acres of elk summer habitat overlap lands that would be available for oil shale leasing. Overall, potential impacts on wildlife and their habitats would be similar in nature to those identified for Alternative 1, but oil shale leasing could occur in less than 1.7% of lands identified for Alternative 1.	110,513 acres of mule deer crucial winter range, 60,871 acres of mule deer winter range, 20,984 acres of mule deer fawning area, 5,021 acres of mule deer migration corridor, 11 acres of moose winter range, 10,486 acres of pronghorn crucial winter range, and 237,866 acres of pronghorn winter range (these acreages are not additive as they do not account for habitat overlap among species or habitat types for a species). A total of 644,774 acres of wild horse HMAs, 821,540 acres of mule deer winter habitat, 171,852 acres of mule deer summer habitat, 813,842 acres of elk winter habitat, and 171,633 acres of elk summer habitat overlap lands that would be available for oil shale leasing.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Wildlife (Cont.)	Potential impacts on wildlife and their habitats would be associated with site clearing and grading, operational noise and activities, accidental releases of hazardous materials, and increased human access to some habitats, and could result in reduced abundance and distribution of affected species. Construction and operation activities could also disturb wildlife in nearby locations and also fragment habitats along project-related ROWs.			Overall, potential impacts on wildlife and their habitats would be similar in nature to those identified for Alternative 1. Oil shale leasing could occur in nearly 97% of lands identified for Alternative 1.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Threatened and Endangered Species	166 federal candidate, BLM-designated sensitive, and state-listed species, and 20 federally listed threatened or endangered species could occur in areas that are available for application for leasing under Alternative 1. Approximately 382,000 acres of land identified in RMPs with existing lease stipulations for the protection of listed or sensitive species would be available for leasing under Alternative 1.	151 federal candidate, BLM-designated sensitive, and state-listed species, and 14 federally listed threatened or endangered species could occur in areas that are available for application for leasing under Alternative 2. Approximately 382,000 acres of land identified in RMPs with existing lease stipulations for the protection of listed or sensitive species would be excluded under Alternative 2.	39 federal candidate, BLM-designated sensitive, and state-listed species, and 9 federally listed threatened or endangered species could occur in areas that are available for application for leasing under Alternative 3.	153 federal candidate, BLM-designated sensitive, and state-listed species, and 20 federally listed threatened or endangered species could occur in areas that are available for application for leasing under Alternative 4.
	Approximately 99 mi of designated critical habitat for Colorado River endangered fishes and 607,087 acres of core habitat areas for the greater sage-grouse occur within lands identified for application for leasing under Alternative 1.	There are no designated critical habitats for ESA-listed species or core habitat areas for the greater sage-grouse within lands identified for application for leasing under Alternative 2.	There are no designated critical habitats for ESA-listed species within lands identified for application for leasing under Alternative 3. However, approximately 2,338 acres of core habitat for the greater sage-grouse occurs within these lands.	Approximately 99 mi of designated critical habitat for Colorado River endangered fishes and 499,688 acres of core habitat areas for the greater sage-grouse occur within lands identified for application for leasing under Alternative 4.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Threatened and Endangered Species (Cont.)	Impacts on threatened and endangered species would be similar to or the same as those described for impacts on aquatic resources, plant communities and habitats, and wildlife. Specific impacts associated with development would depend on the locations of projects relative to species populations and the details of project development.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
	The construction and operation of commercial oil shale projects could impact threatened, endangered, and sensitive species and their habitats where individual projects are located within the 2,017,714 acres currently classified as available for application for leasing. Habitats for threatened, endangered, or sensitive species identified for spatial or temporal protection in BLM RMPs across all three states that would be present in the lease application areas include 46,971 acres for	The construction and operation of commercial oil shale projects could impact threatened, endangered, and sensitive species and their habitats where individual projects are located within the 461,965 acres identified for oil shale leasing. There were no habitats for threatened, endangered, or sensitive species identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas.	The construction and operation of commercial oil shale projects could impact threatened, endangered, and sensitive species and their habitats where individual projects are located within the 32,640 acres identified for oil shale leasing. There were no habitats for threatened, endangered, or sensitive species identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas.	The construction and operation of commercial oil shale projects could impact threatened, endangered, and sensitive species and their habitats where individual projects are located within the 1,963,414 acres identified for oil shale leasing. Habitats for threatened, endangered, or sensitive species identified for spatial or temporal protection in BLM RMPs across all three states that would be present in the lease application areas include 42,088 acres for special status plants,

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Threatened and Endangered Species (Cont.)	special status plants, 26,487 acres for the bald eagle, 2,100 acres for special status raptors other than the bald eagle, 372,347 acres for the sage-grouse, and 38,041 acres for the black-footed ferret.			15,929 acres for the bald eagle, 2,100 acres for special status raptors other than the bald eagle, 368,843 acres for the sage-grouse, and 38,041 acres for the black-footed ferret.
Visual Resources	Commercial oil shale development could impact visual resources on the Alternative 1 lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Visually sensitive areas within the potential lease areas include 10 ACECs, 5 SRMAs, 1 WSR, and 2 river segments eligible for WSR designation. Sensitive areas occurring within 5 mi of the potential lease areas include 8 WSAs, 29 ACECs, 2 SRMAs, 12 WSR segments, 8 National Historic Trails, 2 NWRs, 1 National Historic Landmark,	Commercial oil shale development could impact visual resources on the Alternative 2 lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Potential impacts from project construction and operation would be similar to those identified for Alternative 1. Visually sensitive areas within the potential lease areas include 1 SRMA and 1 WSR. Sensitive areas occurring within 5 mi of the proposed lease areas include 7 WSAs, 24 ACECs, 2 SRMAs, 8 WSRs, 8 National Historic	Commercial oil shale development could impact visual resources on the Alternative 3 lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Potential impacts from project construction and operation would be similar to those identified for Alternative 1. There are no visually sensitive areas within the potential lease areas, while sensitive areas within 5 mi of the lease areas include 7 WSAs, 3 ACECs, and 2 WSRs. These visually sensitive areas could be affected	Commercial oil shale development could impact visual resources on the Alternative 2 lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Potential impacts from project construction and operation would be similar to those identified for Alternative 1. Visually sensitive areas within the potential lease areas include 2 SRMAs and 2 WSRs. Sensitive areas occurring within 5 mi of the proposed lease areas include 8 WSAs, 30 ACECs, 1 SRMA, 12 WSRs, 8 National

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Visual Resources (Cont.)	and 1 national scenic highway. These visually sensitive areas could be affected by future commercial oil shale development within the Alternative 1 lease areas.	Trails, 2 NWRs, 1 National Historic Landmark, and 1 National Scenic Highway. These visually sensitive areas could be affected by future commercial oil shale development within the Alternative 2 lease areas.	by future commercial oil shale development within the Alternative 3 lease areas.	Historic Trails, 2 NWRs, 1 National Historic Landmark, and 1 National Scenic Highway. These visually sensitive areas could be affected by future commercial oil shale development within the Alternative 4 lease areas.
Cultural Resources	Commercial oil shale development could impact cultural resources in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Only some of the cultural resources on the approximately 1.9 million acres that would be available for application for leasing have been identified. Additional resources are likely to exist in the potential leasing area. Some of these resources could be affected by construction and operation of commercial	Commercial oil shale development could impact cultural resources in the Alternative 2 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. The majority of the lands that would be available for application for leasing have the potential to contain important cultural resources. Some of these resources could be affected by construction and operation of commercial projects within the potential lease areas. Potential impacts may include damage or	Portions of the six existing and three proposed RD&D sites have been surveyed for cultural resources, and two of the sites are known to contain cultural resources. Because mitigation is required for RD&D activities, the construction and operation of the nine projects are not expected to significantly impact cultural resources. Some of these resources could be affected by construction and operation of commercial projects within the potential lease areas. Potential impacts may include damage or destruction and increased potential for vandalism or theft due to increased human access.	Commercial oil shale development could impact cultural resources in the Alternative 4 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., power plants and employer-provided housing) would be located. Only some of the cultural resources on the approximately 1.9 million acres that would be available for application for leasing have been identified. Additional resources are likely to exist in the potential leasing area. Some of these resources could be affected by construction and operation of commercial

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Cultural Resources (Cont.)	projects within the potential lease areas. Potential impacts may include damage or destruction and increased potential for vandalism or theft due to increased human access.	destruction and increased potential for vandalism or theft due to increased human access.		projects within the potential lease areas. Potential impacts may include damage or destruction and increased potential for vandalism or theft due to increased human access.
Indian Tribal Concerns	Making land available for application for leasing would not affect resources important to Indian tribes. However, leasing and future development could result in adverse impacts depending on the size and location of the facilities and the technology chosen to develop the lease. Some resources could be affected by the development and operation of commercial projects. Increased access would increase the possibility of destruction, vandalism, and intrusion into sacred sites. Surface mining, with the greatest potential for partial or complete destruction of places	Making land available for application for leasing would not affect resources important to Indian tribes. However, leasing and future development could result in adverse impacts depending on the size and location of the facilities and the technology chosen to develop the lease. Some resources could be affected by the development and operation of commercial projects. Increased access would increase the possibility of destruction, vandalism, and intrusion into sacred sites. The largest land area is protected by surface use restrictions under this alternative. Split estate	Making land available for application for leasing would not affect resources important to Indian tribes. However, leasing and future development could result in adverse impacts depending on the size and location of the facilities and the technology chosen to develop the lease. Some resources could be affected by the development and operation of commercial projects. Increased access would increase the possibility of destruction, vandalism, and intrusion into sacred sites. The fewest resources are likely to be impacted. Split estate parcels on the Uintah and Ouray Ute	Making land available for application for leasing would not affect resources important to Indian tribes. However, leasing and future development could result in adverse impacts depending on the size and location of the facilities and the technology chosen to develop the lease. Some resources could be affected by the development and operation of commercial projects. Increased access would increase the possibility of destruction, vandalism, and intrusion into sacred sites. Split estate parcels on the Uintah and Ouray Ute Reservation could be

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Indian Tribal Concerns (Cont.)	and resources important to tribes, would be allowed in parts of Utah and Wyoming. Split estate parcels on the Uintah and Ouray Ute reservation could be leased, which would affect surface use. Surface use restrictions on excluded areas would afford resources some protection. Required project-specific surveys, analyses, and consultation with affected Indian tribes could reduce impacts on resources within individual parcels.	parcels on the Uintah and Ouray Ute Reservation could be leased, which would affect surface use. Required project-specific surveys, analyses, and consultation with affected Indian tribes could reduce impacts on resources within individual parcels.	Reservation would not be leased. Required project-specific surveys, analyses, and consultation with affected Indian tribes could reduce impacts on resources within individual parcels.	leased, which would affect surface use. Required project-specific surveys, analyses, and consultation with affected Indian tribes could reduce impacts on resources within individual parcels.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Socioeconomics	Construction and operation associated with individual oil shale technologies, including the RD&D facilities would have small to moderate impacts on employment, income, population, housing, public finances, and public service employment in the ROI in each state. Small to moderate impacts on property values and recreation would also occur, and water diversions would also affect agriculture. Rapid increases in population in-migration could impact quality of life, requiring a transition from traditional rural, to more urban lifestyles, and potentially cause large social disruption impacts in some communities.	Same as Alternative 1. Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur.	Same as Alternative 1. Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur.	Same as Alternative 1. Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Environmental Justice	Alternative 1 does not involve land use plan amendments.	Minority or low-income populations within the study area would not incur any impacts from amending land use plans.	Minority or low-income populations within the study area would not incur any impacts from amending land use plans.	Minority or low-income populations within the study area would not incur any impacts from amending land use plans.
	Environmental and human health impacts on the general population are expected to be low. Construction and operation of the six RD&D projects could have minor disproportionate impacts on minority and low-income populations, depending on their location, primarily associated with changes in quality of life and social disruption. Property value and visual impacts would depend on the location of land parcels impacted by oil shale projects. Impacts on minority and low-income populations would also depend on the importance of land parcels for subsistence, their cultural and religious	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Environmental Justice (Cont.)	significance, and their possible alternate economic uses for these populations.			
	Larger scale oil shale project construction and operation could disproportionately impact minority and low-income populations depending on their location. Changes in quality of life and social disruption caused by rapid in-migration of population into rural communities would likely occur, thereby undermining local community social structures and requiring a transition to more urban life styles. The impacts of facility operations on air and water quality and on the demand for water for agriculture in the region could also cause environmental justice impacts. Land use and visual impacts would depend on the location of land parcels impacted by oil	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Environmental Justice (Cont.)	shale projects. Impacts on minority and low-income populations would also depend on the importance of land parcels for subsistence, their cultural and religious significance, and their possible alternate economic uses for these populations.			
Hazardous Materials and Waste Management	Future commercial oil shale development within the potential lease areas in Alternative 1would use and generate hazardous materials and wastes. Hazardous materials would include fuels for equipment and heating, lubricating oils, solvents, and other industrial chemicals, as well as materials produced	The use and generation of hazardous materials and wastes would be of the same nature as those identified for Alternative 1.	The six current and three proposed RD&D projects would use and generate similar types of hazardous materials and wastes. Hazardous materials would include fuels for equipment and heating, lubricating oils, solvents, and other industrial chemicals, as well as materials produced during oil shale processing.	The use and generation of hazardous materials and wastes would be of the same nature as those identified for Alternative 1.

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Hazardous Materials and Waste Management (Cont.)	during oil shale processing. Herbicides may also be used to clear and/or control vegetation at project locations and along utility ROWs. Commercial oil shale development may generate spent shale in large quantities if development by mining occurs; the shale would require management as a waste. The specific types and amounts and their handling and treatment would depend on the specific design of each commercial project. Waste materials would be similar among the six current RD&D projects; these would include solids such as construction debris. Liquid wastes would include both sanitary and industrial wastewater.		Herbicides may also be used to clear and/or control vegetation at project locations and along utility ROWs. Waste materials would also be similar among the RD&D projects; these would include solids such as construction debris. Liquid wastes would include both sanitary and industrial wastewater. Future commercial development within an RD&D PRLA involving mining would generate spent shale, which would require management as a waste.	

TABLE 2.6-1 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Oil Shale Development[a]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 3: Research Lands Focus. Amend Land Use Plans To Identify 32,640 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Colorado, Utah, and Wyoming as Available for Application for Leasing for Commercial Oil Shale Development[b]
Health and Safety	The six current RD&D projects and potential future commercial development of oil shale projects in the Alternative 1 lease area could result in health and safety impacts on workers. These impacts would be associated with accidents causing injuries and fatalities, possible hearing loss from high noise levels, and inhalation of particulates and/or volatiles emitted from the facilities.	Potential health and safety impacts from the six current RD&D projects and potential future commercial developments would be the same as those identified for Alternative 1.	The construction and operation of the six current and three potential RD&D projects could result in health and safety impacts on workers as described for Alternative 1. Injuries from all six current RD&D projects are estimated at about 75 per year during construction and 40 per year during operations; less than 1 fatality per year is estimated for both construction and operations. The future commercial development of oil shale projects in the RD&D PRLAs would have the same types of health and safety impacts as would occur in association with the RD&D projects, but the potential incidence of those impacts would be greater	Potential health and safety impacts from the six current RD&D projects and potential future commercial developments would be the same as those identified for Alternative 1.

Footnotes on next page.

TABLE 2.6-1 (Cont.)

Abbreviations: ACEC = Area of Critical Environmental Concern; AQRV = air quality related value; BLM = Bureau of Land Management; EPA = U.S. Environmental Protection Agency; ESA = Endangered Species Act of 1973; HMA = Herd Management Area; LWC = lands having wilderness characteristics; NEPA = National Environmental Policy Act of 1969; NO_x = nitrogen oxides; NWR = National Wildlife Refuge; O_3 = ozone; PEIS = programmatic environmental impact statement; PFYC = Potential Fossil Yield Classification; PRLA = preference right lease area; RD&D = research, development, and demonstration; RMP = Resource Management Plan; ROI = region of influence; ROW = right-of-way; SRMA = Special Recreation Management Area; VOC = volatile organic compound; WSA = Wilderness Study Area; WSR = Wild and Scenic River.

[a] The adverse impacts of the RD&D projects will be addressed through mitigation measures described in the environmental assessments (EAs) for those projects. All the EAs resulted in Findings of No Significant Impact (BLM 2006c-j; 2007b,c).

[b] Under all alternatives, the nature, magnitude, and extent of project-related impacts of commercial development of oil shale on all resource areas would depend on the type, location, and design of the individual projects.

TABLE 2.6-2 Summary Comparison of Potential Environmental Impacts of Amending Land Use Plans To Identify Lands Available or Not Available for Application for Leasing for the Commercial Development of Tar Sands in Utah, and Environmental Impacts of Future Construction and Operation of Commercial Projects under the Four Alternatives

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Impacts Common To Alternatives 2, 3, and 4	NA[b]	On the basis of the analysis in the PEIS, the BLM has determined that, with the exception noted in the socioeconomic analysis regarding potential impacts on property values, land use plan amendments would not result in any impacts on the environment or socioeconomic setting. However, the future development of commercial tar sands projects that could be approved after subsequent NEPA analysis would have impacts on these resources. The types of impacts that could be associated with future tar sands development are described in Chapter 5 of the PEIS. The magnitude of these potential impacts cannot be quantified at this time because key information about the location of commercial projects, the technologies that may be employed, the project size or production level, development time lines, and mitigation measures that would be applied, are unknown.			

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Land Use	Future commercial tar sands development could affect current land use in the 430,686-acre Alternative 1 lease area. Current land uses such as grazing, irrigated agriculture, recreation, oil and gas production, and mineral extraction would be affected at locations where commercial tar sands projects (and supporting infrastructure) would be located. Additional land use changes would occur on nonfederal lands where project support infrastructure (e.g., employer-provided housing) would be constructed.	Potential impacts on land use from potential commercial development under Alternative 2 would be similar to those identified for Alternative 1 but would potentially affect only about 91,000 acres of federal land.	Potential impacts on land use from the proposed commercial tar sands lease would be similar to those identified for Alternative 1 but would be restricted to only about 2,100 acres of federal land.	Potential impacts on land use from potential commercial development under Alternative 4 would be similar to those identified for Alternative 1 but would potentially affect about 12,000 fewer acres of federal land.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Soil and Geologic Resources	Future commercial tar sands development could affect soil and geologic resources in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Potential impacts would be associated with the construction and operation of project facilities and related infrastructure and would include soil disturbance, soil removal and compaction, subsurface disturbance of geologic resources during drilling and mining, and increased erosion potential of exposed soils and geologic materials.	Potential impacts on soil and geologic resources from commercial tar sands development would be similar to those identified for Alternative 1, but under Alternative 2, impacts could occur at fewer locations and in less geologically sensitive locations.	Potential impacts on soil and geologic resources from development of the Asphalt Ridge STSA would be similar to those identified for Alternatives 1 and 2, but under Alternative 3, impacts would be limited geographically and in overall magnitude.	Similar to Alternative 1.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Paleontological Resources	Impacts could include the destruction of paleontological resources and loss of valuable scientific information within development footprints, degradation and/or destruction of resources and their stratigraphic context within or near the development area, and increased potential for loss of exposed resources from looting or vandalism as a result of increased human access and related disturbance in sensitive areas. Such impacts could be reduced or eliminated by applying mitigation measures; therefore, adverse impacts are not expected. About 78% (335,396 acres) of designated acreage overlies geologic formations having a high potential to contain important paleontological resources (i.e., PFYC 4/5).	The types of potential impacts would be similar to those identified under Alternative 1. Such impacts could be reduced or eliminated by applying mitigation measures; therefore, adverse impacts are not expected. About 88% (80,429 acres) of designated acreage overlies geologic formations having a high potential to contain important paleontological resources (i.e., PFYC 4/5).	The types of potential impacts would be similar to those identified under Alternative 1. Such impacts could be reduced or eliminated by applying mitigation measures; therefore, adverse impacts are not expected. About 69% (1,458 acres) of designated acreage overlies geologic formations having a high potential to contain important paleontological resources (i.e., PFYC 4/5).	The types of potential impacts would be similar to those identified under Alternative 1. Such impacts could be reduced or eliminated by applying mitigation measures; therefore, adverse impacts are not expected. About 80% (335,396 acres) of designated acreage overlies geologic formations having a high potential to contain important paleontological resources (i.e., PFYC 4/5).

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Water Resources	Commercial tar sands development could impact water resources in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Potential project-related impacts may include reduced water quality due to erosion and sedimentation, dewatering of local aquifers, and contamination of surface water or groundwater by accidental releases of hazardous materials. The Alternative 1 potential lease areas (including a 2-mi buffer zone) include about 185 mi of perennial streams that could be affected by commercial project development, or 68% of the perennial streams in the STSAs.	Potential impacts on water resources from future construction and operation of commercial tar sands projects in the Alternative 2 potential lease areas would be similar to those identified for Alternative 1. Alternative 2 excludes from lease application about 200,000 acres of land that is currently identified in BLM land use plans as having steep slopes and/or fragile or highly erosive soils and included under Alternative 1. Thus, there is a reduced potential for erosion-related impacts with commercial tar sands development under Alternative 2. The Alternative 2 potential lease areas (including a 2-mi buffer zone) include about 125 mi of perennial streams that could be affected by commercial project development, or 46% of the perennial streams in the STSAs.	Potential impacts on water resources from development of the Asphalt Ridge STSA would be similar to those identified for Alternatives 1 and 2, but under Alternative 3, impacts would be limited geographically and in overall magnitude. No perennial streams flow through the STSA, thus reducing the likelihood of impacts on surface water quality.	Similar to Alternative 1.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Air Quality	Commercial tar sands development could impact air quality in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. The construction and operation of future commercial tar sands projects could result in local and regional impacts on air quality and AQRVs, such as visibility and acid deposition. These impacts could result from heavy equipment and vehicle emissions, fugitive dust generation from construction and mining areas and along some access roads, and tar sands processing emissions. In addition, O_3 precursors of NO_x and VOCs from tar sands development could exacerbate wintertime high-O_3 occurrences already prevalent in the study area, especially in Uintah County, Utah.	Commercial tar sands development could impact air quality in the Alternative 2 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Potential local and regional impacts on air quality and AQRVs would be similar in nature to those identified for Alternative 1. However, Alternative 2 has approximately 340,000 fewer (about 79%) acres of land than Alternative 1 where future commercial tar sands development could occur and affect local or regional air quality and AQRVs. And, thus, the magnitude of potential impacts is anticipated to be far less than that for Alternative 1.	The proposed commercial tar sands lease could impact air quality in the project area and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Potential local and regional impacts on air quality and AQRVs would be similar in nature to those identified for Alternative 1. However, because of its far smaller lease areas (about 0.5% of land for Alternative 1), the magnitude of potential impacts is anticipated to be minimal compared to that for Alternative 1.	Commercial tar sands development could impact air quality in the Alternative 4 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Potential local and regional impacts on air quality and AQRVs would be similar in nature and magnitude to those identified for Alternative 1. Alternative 4 has only approximately 12,250 fewer (about 3%) acres of land than Alternative 1 where future commercial tar sands development could occur and affect local or regional air quality and AQRVs.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Air Quality (Cont.)	Because of the need for project- and site-specific information, it is not possible to identify the nature and magnitude of regional air quality impacts from commercial development within the Alternative 1 potential lease areas.			
Noise	Commercial tar sands development could affect noise levels in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. In most cases, noise is considered a local problem, not a regional problem. Localized noise levels (i.e., increased noise levels) could be affected by construction activities, mining, processing equipment, pipeline compressor stations, and vehicle traffic.	Commercial tar sands development could impact noise levels in the Alternative 2 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Localized noise impacts would be similar in nature and magnitude to those identified for Alternative 1. Changes in ambient noise levels due to project development could occur wherever a project is located within the 91,045 acres identified for application for	The proposed commercial tar sands lease could affect noise levels in the Alternative 3 potential lease area and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located.	Commercial tar sands development could affect noise levels in the Alternative 4 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Localized noise impacts would be similar in nature and magnitude than those identified for Alternative 1. Changes in ambient noise levels due to project development could occur wherever a project is located within more than 1.9 million acres identified for application

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Noise (Cont.)	Noise levels from tar sands development could exceed EPA guidelines for receptors in close proximity but would not be exceeded at farther receptor locations (e.g., beyond 0.5 mi).	leasing under Alternative 2, which is about 340,000 fewer (about 79%) acres of land than for Alternative 1.	Localized noise impacts would be similar in nature and magnitude than those identified for Alternative 1. Changes in ambient noise levels due to project development could occur wherever a project is located within the 2,100 acres identified for application for leasing under Alternative 3, which is only about 0.5% of land for Alternative 1.	for leasing under Alternative 2, which is about 12,250 fewer (about 3%) acres of land than for Alternative 1.
Ecological Resources (resource subgroups summarized below)	Ecological resources could be affected in areas available for application for leasing of tar sands resources. Impacts related to tar sands development may include wildlife disturbance, habitat loss, exposure to accidental releases of hazardous materials, the spread or establishment of invasive species, and the loss or injury of biota within physically disturbed areas related to the projects (including utility ROWs and access roads).	Commercial tar sands development could impact ecological resources in Alternative 2 potential lease areas in the same manner as Alternative 1 but on approximately 340,000 fewer acres, some of which are excluded because of the presence of sensitive ecological resources. Indirect impacts would be the same as Alternative 1.	The proposed commercial tar sands lease could impact ecological resources in Alternative 3 potential lease areas in the same manner as Alternative 1 but on approximately 429,000 fewer acres of land. Indirect impacts would be the same as Alternative 1.	Commercial tar sands development could impact ecological resources in Alternative 4 potential lease areas in the same manner as Alternative 1 but on about 12,250 fewer acres of land. Indirect impacts would be the same as Alternative 1.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Ecological Resources (resource subgroups summarized below) (Cont.)	Indirect impacts such as those related to surface and groundwater withdrawals could occur in more distant but hydrologically connected areas.			
Aquatic Resources	For Alternative 1, there are 20 perennial streams totaling about 185 mi of perennial stream habitat within the lease areas (including a 2-mi buffer). The construction and operation of commercial tar sands projects within the potential leases areas could adversely affect aquatic resources by directly disturbing aquatic habitat or by contaminant inputs and surface water depletions resulting from groundwater and surface water use. The development of infrastructure, such as roads and ROWs, could increase public access to fishery resources. Potential impacts could result in habitat loss or degradation, affecting the abundance and distribution of aquatic biota in the affected habitats.	For Alternative 2, there are 12 perennial streams totaling about 125 mi of perennial stream habitat within the lease areas (including a 2-mi buffer). Potential types of impacts would be similar to those identified for Alternative 1 and could result in habitat loss or degradation, which could affect the abundance and distribution of aquatic biota in the affected habitats.	For Alternative 3, there are no perennial streams within the proposed lease area (including a 2-mi buffer). Therefore, there are no direct impacts on aquatic habitats associated with this land use designation. However, impacts on aquatic biota could potentially occur from water depletions.	For Alternative 4, there are 20 perennial streams totaling about 188 mi of perennial stream habitat within the lease areas (including a 2-mi buffer). Potential types of impacts would be similar to those identified for Alternative 1 and could result in habitat loss or degradation, which could affect the abundance and distribution of aquatic biota in the affected habitats.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Plant Communities and Habitats	The construction and operation of commercial tar sands projects could impact plant communities and habitats that are present in the Alternative 1 potential lease areas. The potential lease areas include about 6,874 acres that have been identified for the protection of floodplains, riparian habitats, and special status plant species. Impacts could include the direct loss of vegetation from site clearing and grading; reduced habitat quality due to soil compaction, dewatering, water quality reduction, erosion, sedimentation, or accidental releases of hazardous materials; and the introduction or spread of invasive species. Utility and access road ROWs could also result in the fragmentation of some habitats. Alternative 1 areas also include a portion of 1 ACEC and are adjacent to or near 6 ACECs designated for sensitive plants or plant communities.	The construction and operation of commercial tar sands projects could impact plant communities and habitats that occur in Alternative 2 potential lease areas. The areas where commercial development could occur do not include land currently identified for protection of floodplains, riparian habitats, and special status plant species. Potential impacts would be similar in nature to those identified for Alternative 1 but could occur in fewer locations. Alternative 2 areas do not include ACECs but are adjacent to or near 5 ACECs designated for sensitive plants or plant communities.	The construction and operation of commercial tar sands projects in prospective lease areas in the Asphalt Ridge STSA under Alternative 3 could affect plant communities and habitats. The areas available for application for leasing do not include land currently identified for the protection of riparian habitat, floodplains, or special status plant species. Alternative 3 areas are not in or near ACECs designated for sensitive plants or plant communities.	The construction and operation of commercial tar sands projects could impact plant communities and habitats that occur in Alternative 4 potential lease areas. The areas where commercial development could occur include about 6,859 acres that have been identified for the protection of floodplains, riparian habitats and special status plant species. Potential impacts would be similar in nature to those identified for Alternative 1 but could occur in fewer locations. Alternative 4 areas do not include ACECs but are adjacent to or near 7 ACECs designated for sensitive plants or plant communities.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Wildlife	The construction and operation of commercial tar sands projects could impact wildlife and their habitats where individual projects are located within the 430,686 acres currently classified as available for tar sands leasing. Wildlife habitats identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas include 7 acres of raptor nests, 112,809 acres of elk crucial winter range, 26,804 acres of elk calving habitat, 96,564 acres of mule deer crucial winter range, 23,584 acres of mule deer fawning habitat, and 41,588 acres of mule deer migration corridor (these acreages are not additive as they do not account for habitat overlap among species or habitat types for a species). A total of 77,409 acres of wild horse and burro HMAs,	The construction and operation of commercial tar sands projects could impact wildlife and their habitats where individual projects are located within the 91,045 acres identified for tar sands leasing. There were no habitats for wildlife identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas. A total of 17,572 acres of wild horse HMAs, 57,708 acres of mule deer winter habitat, 17,110 acres of mule deer summer habitat, 52,361 acres of elk winter habitat, and 17,170 acres of elk summer habitat overlap lands that would be available for tar sands leasing. Overall, potential impacts on wildlife and their habitats would be similar in nature to those identified for Alternative 1, but tar sands leasing could occur in	The construction and operation of the proposed commercial tar sands project could impact wildlife and their habitats where facilities are located within the 2,100 acres identified for tar sands leasing. Wildlife habitats identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas include 41 acres of mule deer fawning habitat. No wild horse HMAs, mule deer summer habitat, or elk winter and summer habitats overlap tar sands areas included in Alternative 3. A total of 1,729 acres of mule deer winter habitat overlap lands that would be available for tar sands leasing. Overall, potential impacts on wildlife and their habitats would be similar in nature to those identified for Alternative 1, but tar sands leasing could occur in	The construction and operation of commercial tar sands projects could impact wildlife and their habitats where individual projects are located within the 425,790 acres identified for tar sands leasing. Wildlife habitats identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas include 5 acres of raptor nests, 112,809 acres of elk crucial winter range, 26,804 acres of elk calving habitat, 96,564 acres of mule deer crucial winter range, 23,584 acres of mule deer fawning habitat, and 41,588 acres of mule deer migration corridor (these acreages are not additive as they do not account for habitat overlap among species or habitat types for a species). A total of 77,287 acres of wild horse HMAs, 225,508 acres of mule deer winter habitat,

TABLE 2.6-2 (Cont.)

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Wildlife (Cont.)	228,122 acres of mule deer winter habitat, 77,172 acres of mule deer summer habitat, 194,354 acres of elk winter habitat, and 65,366 acres of elk summer habitat overlap lands that would be available for tar sands leasing. Potential impacts on wildlife and their habitats would be associated with site clearing and grading, operational noise and activities, accidental releases of hazardous materials, and increased human access to some habitats, and could result in reduced abundance and distribution of affected species. Construction and operation activities could also disturb wildlife in nearby locations and also fragment habitats along project-related ROWs.	only about 21% of lands identified for Alternative 1.	less than 0.5% of lands identified for Alternative 1.	77,172 acres of mule deer summer habitat, 198,324 acres of elk winter habitat, and 65,366 acres of elk summer habitat overlap lands that would be available for tar sands leasing. Overall, potential impacts on wildlife and their habitats would be similar in nature to those identified for Alternative 1. Tar sands leasing could occur in about 99% of lands identified for Alternative 1.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Threatened and Endangered Species	58 federal candidate, BLM-designated sensitive, and state-listed species, and 20 federally listed threatened or endangered species could occur in areas that are available for leasing under Alternative 1. Approximately 2,200 acres of designated critical habitat for the Mexican spotted owl and 117,716 acres of core habitat areas for the greater sage-grouse occur within lands identified for application for leasing under Alternative 1. The construction and operation of commercial tar sands projects could impact threatened, endangered, and sensitive species and their habitats where individual projects are located within the 430,686 acres currently classified as available for application for leasing. Habitats for threatened,	50 federal candidate, BLM-designated sensitive, and state-listed species, and 20 federally listed threatened or endangered species could occur in areas that are available for leasing under Alternative 2. Approximately 471 acres of designated critical habitat for the Mexican spotted owl occur within lands identified for application for leasing under Alternative 2. However, there are no core habitat areas for the greater sage-grouse in lands identified under Alternative 2. The construction and operation of commercial tar sands projects could impact threatened, endangered, and sensitive species and their habitats where individual projects are located within the 91,045 acres identified for oil shale leasing. There were no habitats for	23 federal candidate, BLM-designated sensitive, and state-listed species, and 7 federally listed threatened or endangered species could occur in areas that are available for leasing under Alternative 3. There are no designated critical habitats for ESA-listed species within lands identified for application for leasing under Alternative 3. However, approximately 2,100 acres of core habitat areas for the greater sage-grouse occur in lands identified under Alternative 3. The construction and operation of commercial tar sands projects could impact threatened, endangered, and sensitive species and their habitats where individual projects are located within the 2,100 acres identified for oil shale leasing. Habitats for threatened, endangered, or	53 federal candidate, BLM-designated sensitive, and state-listed species, and 22 federally listed threatened or endangered species could occur in areas that are available for leasing under Alternative 4. Approximately 27,200 acres of designated critical habitat for the Mexican spotted owl and 87,780 acres of core habitat areas for the greater sage-grouse occur within lands identified for application for leasing under Alternative 4. The construction and operation of commercial tar sands projects could impact threatened, endangered, and sensitive species and their habitats where individual projects are located within the 418,976 acres identified for oil shale leasing. Habitats for threatened, endangered, or sensitive species

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Threatened and Endangered Species (Cont.)	endangered, or sensitive species identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas include 1,625 acres for Graham's penstemon, 36 acres for the bald eagle, and 42,017 acres for the sage-grouse.	threatened, endangered, or sensitive species identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas.	sensitive species identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas include 1,638 acres for the sage-grouse.	identified for spatial or temporal protection in BLM RMPs that would be present in the lease application areas include 1,625 acres for Graham's penstemon, 36 acres for the bald eagle, and 42,017 acres for the sage-grouse.
Visual Resources	Commercial tar sands development could impact visual resources in the Alternative 1 lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Short- and long-term visual impacts may result with the construction and operation of the projects and would be associated with construction activities at each site and along associated ROWs. Additional visual impacts may be associated with the presence of site facilities	Potential impacts from project construction and operation would be similar in nature to those identified for Alternative 1. Visually sensitive areas within the proposed lease areas include 1WSA. Sensitive areas within 5 mi of the lease areas include 17 ACECs, 16 WSAs, 4 SRMAs, 1 NRA, 1 National Scenic Highway, and 3 state- or agency-designated scenic highways. These visually sensitive areas could be subject to large visual impacts from future commercial tar sands development within the Alternative 1 lease areas.	Potential impacts from project construction and operation would be similar in nature to those identified for Alternative 1. Visually sensitive areas within the proposed tar sands lease area include 1 National Scenic Highway. Sensitive areas within 5 mi of the lease area include 1 National Scenic Highway.	Potential impacts from project construction and operation would be similar in nature to those identified for Alternative 1. Visually sensitive areas within the proposed lease areas include 1 SRMA, 1 National Scenic Highway, and one state-designated scenic highway. Sensitive areas within 5 mi of the lease areas include 19 ACECs, 18 WSAs, 5 SRMAs, 2 National Scenic Highways, and 3 state- or agency-designated scenic highways.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Visual Resources (Cont.)	within viewsheds and lighting pollution.	Smaller impacts could occur at greater distances from the lease areas.		
Cultural Resources	Commercial tar sands development could impact cultural resources in the Alternative 1 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Some of the land that would be available for application for leasing has been examined for cultural resources. Significant cultural resources were identified in these areas. Additional undiscovered resources are likely to exist in the unsurveyed portions of the potential lease areas. Important cultural resources could be affected by construction and operation of commercial projects within the potential lease areas. Potential impacts may include damage or	Commercial tar sands development could impact cultural resources in the Alternative 2 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Some of the land that would be available for application for leasing has been examined for the presence of cultural resources. Some of the resources identified could be affected by construction and operation of commercial projects within the potential lease areas. Potential impacts may include damage or destruction and increased potential for vandalism or theft due to increased human access.	Some of the 2,100 acres in the proposed tar sands lease have the potential to contain important cultural resources. Potential impacts on these resources from commercial tar sands development within the Alternative 3 potential lease areas would be similar to those identified for Alternative 1 but could occur in fewer locations.	Commercial tar sands development could impact cultural resources in the Alternative 4 potential lease areas and at locations on nonfederal lands where project-related infrastructure (e.g., employer-provided housing) would be located. Some of the land that would be available for application for leasing has been examined for cultural resources. Significant cultural resources were identified in these areas. Additional undiscovered resources are likely to exist in the unsurveyed portions of the potential lease areas. Important cultural resources could be affected by construction and operation of commercial projects within the potential lease areas. Potential impacts may include damage or

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Cultural Resources (Cont.)	destruction and increased potential for vandalism or theft due to increased human access.			destruction and increased potential for vandalism or theft due to increased human access.
Indian Tribal Concerns	Making land available for application for leasing would not affect resources important to Indian tribes. However, leasing and future development could result in adverse impacts depending on the size and location of the facilities and the technology chosen to develop the lease. Some resources could be affected by the development and operation of commercial projects, which all involve widespread surface disturbance. Increased access would increase the possibility of damage, destruction, vandalism, and intrusion into sacred sites. This alternative makes the most land available for potential future development and includes only current land exclusions with	Making land available for application for leasing would not affect resources important to Indian tribes. However, leasing and future development could result in adverse impacts depending on the size and location of the facilities and the technology chosen to develop the lease. Some resources could be affected by the development and operation of commercial projects, which all involve widespread surface disturbance. Increased access would increase the possibility of damage, destruction, vandalism, and intrusion into sacred sites. This alternative makes significantly less land available than Alternatives 1 or 4 but much more than Alternative 3, thus	The proposed commercial tar sands lease could result in adverse impacts depending on the size and location of the facilities and the technology chosen to develop the lease. Some resources could be affected by the proposed commercial project, which could involve widespread surface disturbance. Increased access could increase the possibility of damage, destruction, vandalism, and intrusion into sacred sites. This alternative makes the least land available. Surface mining may be allowed.	Making land available for application for leasing would not affect resources important to Indian tribes. However, leasing and future development could result in adverse impacts depending on the size and location of the facilities and the technology chosen to develop the lease. Some resources could be affected by the development and operation of commercial projects, which all involve widespread surface disturbance. Increased access would increase the possibility of destruction, vandalism, and intrusion into sacred sites. More land is excluded from development than under Alternative 1 but less than under Alternative 2. Surface mining would be allowed.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Indian Tribal Concerns (Cont.)	surface use restrictions. Surface mining would be allowed. Required project-specific surveys, analyses, and consultation with affected Indian tribes could reduce impacts on resources within individual parcels.	reducing the likelihood of adverse impacts. Surface mining would be allowed. Required project-specific surveys, analyses, and consultation with affected Indian tribes could reduce impacts on resources within individual parcels.	Required project-specific surveys, analyses, and consultation with affected Indian tribes could reduce impacts on resources within individual parcels.	Required project-specific surveys, analyses, and consultation with affected Indian tribes could reduce impacts on resources within individual parcels.
Socioeconomics	Construction and operation associated with individual tar sands technologies would have small to moderate impacts on employment, income, population, housing, public finances, and public service employment in the ROI. Small to moderate impacts on property values and recreation would also occur, and water diversions would also affect agriculture. Rapid increases in population in-migration could impact quality of life, requiring a transition from traditional rural,	Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur. Potential project impacts would be similar to those identified for Alternative 1.	Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur. Potential project impacts for the commercial tar sands lease would be similar to those identified for Alternative 1.	Socioeconomic impacts could occur within the study area from amending land use plans; specifically, changes in property values could occur. Potential project impacts would be similar to those identified for Alternative 1.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Socioeconomics (Cont.)	to more urban lifestyles, and potentially cause large social disruption impacts.			
Environmental Justice	Tar sands project construction and operation would disproportionately impact minority and low-income populations depending on their location. Changes in quality of life caused by rapid in-migration of population into rural communities would likely occur, thereby undermining local community social structures and requiring a transition to more urban life styles. Social disruption would also occur. The impacts of facility operations on air and water quality and on the demand for water for agriculture in the region could also cause environmental justice impacts. Land use and visual impacts would depend on the location of land parcels impacted by tar sands projects. Impacts on minority and low-income	Potential project impacts would be similar to those identified for Alternative 1.	Impacts from the proposed commercial tar sands lease would be similar to those identified for Alternative 1.	Potential project impacts would be similar to those identified for Alternative 1.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Environmental Justice (Cont.)	populations would also depend on the importance of land parcels for subsistence, their cultural and religious significance, and their possible alternate economic uses to these populations.			
Hazardous Materials and Waste Management	Future commercial tar sands development within the Alternative 1 potential lease areas would use and generate similar types of hazardous materials and wastes. Spent tar sands may also be generated in large quantities if development by mining occurs; the spent tar sands would require management as a waste. The specific types and amounts and their handling and treatment would depend on the specific design of each commercial project.	For individual projects, the types and amounts of hazardous materials and wastes that could be used and generated during commercial tar sands development would be the same as those identified for Alternative 1.	For the proposed tar sands project, the types and amounts of hazardous materials and wastes that could be used and generated during commercial tar sands development would be the same as those identified for Alternative 1.	For individual projects, the types and amounts of hazardous materials and wastes that could be used and generated during commercial tar sands development would be the same as those identified for Alternative 1.

TABLE 2.6-2 (Cont.)

Resource	Alternative 1: No Action. 2,017,714 Acres Currently Classified as Available for Leasing in the Existing White River and Book Cliffs RMPs. No Land Use Plans Would Be Amended To Allow for Additional Tar Sands Development[b]	Alternative 2: Conservation Focus. Amend Land Use Plans To Identify 461,965 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 3: Pending Commercial Lease. Identify 2,100 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]	Alternative 4: Moderate Development: Amend Land Use Plans To Identify 1,963,414 Acres of Federal Land in Utah as Available for Application for Leasing for Commercial Tar Sands Development[a]
Health and Safety	Commercial tar sands project development may result in worker injuries or fatalities from accidents, possible hearing loss from high noise levels, and inhalation of particulates and/or VOCs.	Potential health and safety impacts from project construction and operation would be similar to those identified for Alternative 1 and identical for projects with identical plans of development and located in common lease areas.	Potential health and safety impacts from construction and operation of the proposed tar sands project would be similar to those identified for Alternative 1.	Potential health and safety impacts from project construction and operation would be similar to those identified for Alternative 1 and identical for projects with identical plans of development and located in common lease areas.

Abbreviations: ACEC = Area of Critical Environmental Concern; AQRV = air quality related value; BLM = Bureau of Land Management; EPA = U.S. Environmental Protection Agency; ESA = Endangered Species Act of 1973; HMA = Herd Management Area; NEPA = National Environmental Policy Act of 1969; NO_x = nitrogen oxides; NRA = National Recreation Area; O_3 = ozone; PEIS = programmatic environmental impact statement; PFYC = Potential Fossil Yield Classification; RD&D = research, development, and demonstration; RMP = Resource Management Plan; ROI = region of influence; ROW = right-of-way; SRMA = Special Recreation Management Area; STSA = Special Tar Sands Areas; VOC = volatile organic compound; WSR = Wild and Scenic River.

[a] Under all alternatives, the nature, magnitude, and extent of project-related impacts of commercial development of tar sands on all resource areas would depend on the type, location, and design of the individual projects.

[b] NA = not applicable.

2.7 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.

BLM (Bureau of Land Management), 1984, *Utah Combined Hydrocarbon Leasing Regional Final EIS: Volume I, Regional Analyses*, Richfield District Office, Richfield, Utah, June.

BLM, 1987, *Grand Junction Resource Area Resource Management Plan and Record of Decision*, Grand Junction District, Colo., Jan.

BLM, 1988, *Record of Decision and Resource Management Plan*, Glenwood Springs Resource Area, Grand Junction District, Colo., June.

BLM, 1997a, *Record of Decision and Green River Resource Management Plan*, Green River Resource Area, Rock Springs District Office, Wyo., Oct.

BLM, 1997b, *White River Record of Decision and Approved Resource Management Plan*, White River Resource Area, Colo., Craig District, Meeker, Colo., July.

BLM, 2005, *Land Use Planning Handbook*, BLM Handbook H-1601-1, Washington, D.C., March.

BLM, 2006a, *Record of Decision and Jack Morrow Hills Coordinated Activity Plan/Proposed Green River Resource Management Plan Amendment*, Rock Springs Field Office, Wyo., July.

BLM, 2006b, *Roan Plateau Planning Area, Including Former Naval Oil Shale Reserves Numbers 1 & 3, Resource Management Plan Amendment & Environmental Impact Statement, Final*, Colorado State Office, Aug. Available at http://www.blm.gov/rmp/co/roanplateau/final_eis_document.htm.

BLM, 2006c, *Environmental Assessment, Chevron Oil Shale Research, Development & Demonstration*, CO-110-2006-120-EA, White River Field Office, Meeker, Colo., Nov.

BLM, 2006d, *Finding of No Significant Impact and Decision Record, COC 69165, Chevron U.S.A. Oil Shale Research, Development and Demonstration*, for Environmental Assessment CO-110-2006-120-EA, White River Field Office, Meeker, Colo., Nov. 9.

BLM, 2006e, *Environmental Assessment, EGL Resources, Inc., Oil Shale Research, Development and Demonstration Tract*, CO-110-2006-118-EA, White River Field Office, Meeker, Colo., Oct.

BLM, 2006f, *Finding of No Significant Impact and Decision Record, COC 69169, EGL Resources, Inc., Oil Shale Research, Development and Demonstration Tract*, for Environmental Assessment CO-110-2006-118-EA, White River Field Office, Meeker, Colo., Nov. 9.

BLM, 2006g, *Environmental Assessment, Shell Oil Shale Research, Development and Demonstration Projects, Rio Blanco County, Colorado*, CO-110-2006-117-EA, White River Field Office, Meeker, Colo., Nov.

BLM, 2006h, *Finding of No Significant Impact/Decision Record, Site 1, COC-69167, Oil Shale Test Site, Shell Frontier Oil and Gas Inc., Oil Shale Research, Development and Demonstration Pilot*, for Environmental Assessment CO-110-2006-117-EA, White River Field Office, Meeker, Colo., Nov. 9.

BLM, 2006i, *Finding of No Significant Impact/Decision Record, Site 2, COC-69166, Oil Shale Test Site, Shell Frontier Oil and Gas Inc., Oil Shale Research, Development and Demonstration Pilot*, for Environmental Assessment CO-110-2006-117-EA, White River Field Office, Meeker, Colo., Nov. 9.

BLM, 2006j, *Finding of No Significant Impact/Decision Record, Site 3, COC-69194, Oil Shale Test Site, Shell Frontier Oil and Gas Inc., Oil Shale Research, Development and Demonstration Pilot*, for Environmental Assessment CO-110-2006-117-EA, White River Field Office, Meeker, Colo., Nov. 9.

BLM, 2007a, *Record of Decision for the Approval of Portions of the Roan Plateau Management Plan Amendment and Environmental Impact Statement*, Glenwood Springs Field Office, Colo., June.

BLM, 2007b, *Environmental Assessment, Oil Shale Research, Development and Demonstration Project, White River Mine, Uintah County, Utah,* UT-080-06-280, Vernal Field Office, Vernal, Utah, April.

BLM, 2007c, *Finding of No Significant Impact/Decision Record, Oil Shale Exploration Company, Oil Shale Research, Development and Demonstration Project, UTU-84087, Location: White River Mine, Uintah County, Utah,* for Environmental Assessment UT-080-06-280-EA, Vernal Field Office, Vernal, Utah, April 30.

BLM, 2008a, *Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocation in Colorado, Utah, and Wyoming and Final Programmatic Environmental Impact Statement,* FES 08-32, Sept. Available at http://ostseis.anl.gov/.

BLM, 2008b, *Record of Decision for the Oil Shale and Tar Sands Resources Resource Management Plan Amendments,* Nov. 17.

BLM, 2008c, *Record of Decision for the Resource Management Plan Amendment for Portions of the Roan Plateau Planning Area Designated as Areas of Critical Environmental Concern Public Lands in Garfield County, CO*, March.

BLM, 2008d, *Proposed Resource Management Plan and Final Environmental Impact Statement*, Monticello Field Office, Utah, Aug.

BLM, 2008e, *Proposed Resource Management Plan and Final Environmental Impact Statement for the Price Field Office*, Price Field Office, Utah, Aug.

BLM, 2008f, *Richfield Field Office Proposed Resource Management Plan & Final Environmental Impact Statement*, Richfield Field Office, Utah, Aug.

BLM, 2008g, *Proposed Resource Management Plan Revision and Final Environmental Impact Statement for the Vernal Field Office Planning Area,* Vernal Field Office, Utah, Aug.

BLM, 2008h, *Record of Decision and Approved Resource Management Plan*, Rawlins District Office, Great Divide Resource Area, Wyo.,

BLM, 2010, *Record of Decision for the Kemmerer Resource Management Plan and Rangeland Program Summary Document*, Kemmerer Resource Area, Rock Springs District, Wyo.

DOI (U.S. Department of the Interior), 1968, "Oil and Gas Leases for Lands in Oil Shale Areas," *Federal Register*, Vol. 33, No. 193, Oct. 2.

Donnell J.R., 1987, "Storehouse of Energy Minerals in the Piceance Basin," in *Oil Shale, Water Resources, and Valuable Minerals of the Piceance Basin, Colorado: The Challenge and Choices of Development*, O.J. Taylor (editor), U.S. Geological Survey Professional Paper 1310.

EPA (U.S. Environmental Protection Agency), 1974, *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, EPA 550/9-74-004, Office of Noise Abatement and Control, Washington, D.C., March.

ExxonMobil, 2011, *Oil Shale Research, Development and Demonstration (RD&D) Lease Plan of Operation*, ExxonMobil Upstream Research Company, Houston, Texas.

Meyer, R., 1995, "Bitumen," in *Encyclopedia of Energy Technology and the Environment,* Vol. 1, A. Bisio and S. Boots (editors), John Wiley & Sons, New York, N.Y.

Natural Soda Holdings Inc., 2011, *2011 Plan of Operation, Oil Shale Research, Development and Demonstration (RD&D), Tract COC 74299*, prepared by Daub & Associates, Inc., Grand Junction, Colo., for Natural Soda Holdings, Inc., Piceance Creek Basin, Rio Blanco County, Colo.

Tabet, D., 2007, personal communication from Tabet (Utah Geological Survey, Salt Lake City, Utah) to S.J. Thompson (Bureau of Land Management, Washington, D.C., Office), Dec. 14.

USDC Colorado, 2011, United States District Court for the District of Colorado, Case 1:09-cv-00085-JLK, Document 63-1, filed Feb. 15, 2011.

U.S. President, 1930, "Withdrawal of Public Oil-Shale Deposits, and Lands Containing Same for Investigation, Examination, and Classification" Executive Order 5327, April 15.

U.S. President, 1978, "Federal Compliance with Pollution Control Standards," Executive Order 12088, *Federal Register* 43: 47707, Oct. 17.

U.S. President, 1994, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," Executive Order 12898, *Federal Register* 59:7629, Feb. 11.

U.S. President, 1997, "Protection of Children from Environmental Health Risks and Safety Risks," Executive Order 13045, *Federal Register* 62:19883–19888, April 23.

U.S. President, 2000, "Greening of Government through Leadership in Environmental Management," Executive Order 13148, *Federal Register* 65:24595, April 20.

USGS (U.S. Geological Survey), 1980a, *Argyle Canyon–Willow Creek, Utah Tar Sand Leasing Minutes No. 9*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980b, *Asphalt Ridge–Whiterocks and Vicinity, Utah Tar Sand Leasing Minutes No. 3*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980c, *Circle Cliffs East and West Flanks, Utah Tar Sand Leasing Minutes No. 5*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980d, *Hill Creek, Utah Tar Sand Leasing Minutes No. 6*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980e, *Pariette, Utah Tar Sand Leasing Minutes*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980f, *P.R. Spring, Utah Tar Sand Leasing Minutes*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980g, *Raven Ridge–Rim Rock and Vicinity, Utah Tar Sand Leasing Minutes No. 8*, Minutes of the Mineral Land Evaluation Committee, Nov. 10

USGS, 1980h, *San Rafael Swell, Utah Tar Sand Leasing Minutes No. 7*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980i, *Sunnyside and Vicinity, Utah Tar Sand Leasing Minutes No. 4*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980j, *Tar Sand Triangle, Utah Tar Sand Leasing Minutes No. 2*, Minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980k, *White Canyon, Utah Tar Sand Leasing Minutes No. 11*, Minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 2010a, *Oil Shale and Nahcolite Resources of the Piceance Basin, Colorado,* National Oil and Gas Assessment Project, Digital Data Series DDS–69–Y, U.S. Geological Survey Oil Shale Assessment Team.

USGS 2010b, *Oil Shale Resources of the Uinta Basin, Utah and Colorado*, National Oil and Gas Assessment Project, Digital Data Series DDS–69–BB, U.S. Geological Survey Oil Shale Assessment Team.

USGS, 2011, *Oil Shale Resources of the Eocene Green River Formation, Greater Green River Basin, Wyoming, Colorado, and Utah,* National Oil and Gas Assessment Project, Digital Data Series DDS–69–DD, U.S. Geological Survey Oil Shale Assessment Team

Wiig, S., 2006a, personal communication from Wiig (BLM Rock Springs Field Office, Wyo.) to P. Perlewitz (BLM Wyoming State Office, Cheyenne, Wyo.), June 13.

Wiig, S., 2006b, personal communication from Wiig (BLM Rock Springs Field Office, Wyo.) to K.P. Smith (Argonne National Laboratory, Lakewood, Colo.), June 27.

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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.)

[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 1988) 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.

Much of the oil shale resource 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). 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 Amendment, for which a Final EIS was issued in 2006 (BLM 2006a), was prepared to develop an integrated management strategy that

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

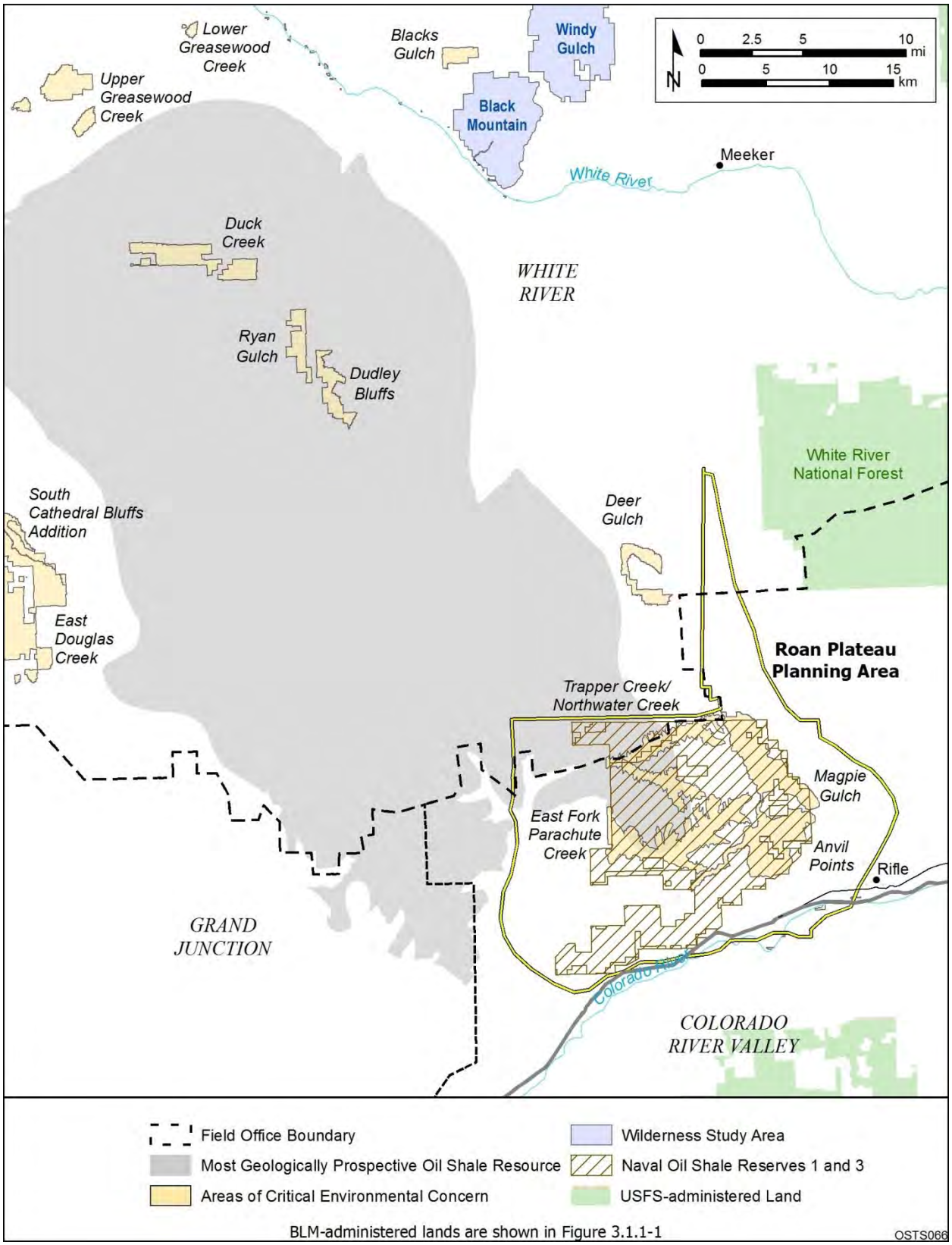

FIGURE 3.1.1-2 BLM Planning Areas in Colorado Where Oil Shale Resources Are Located

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 purported to open these NOSRs (Nos. 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 will also be identified as 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 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 to be attached to oil and gas leases were identified 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 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 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 considered necessary because existing regulations, policies, and land use decisions were adequate to manage the oil shale resources.

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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).

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 summer 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 pending RD&D leases currently undergoing NEPA analysis 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 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

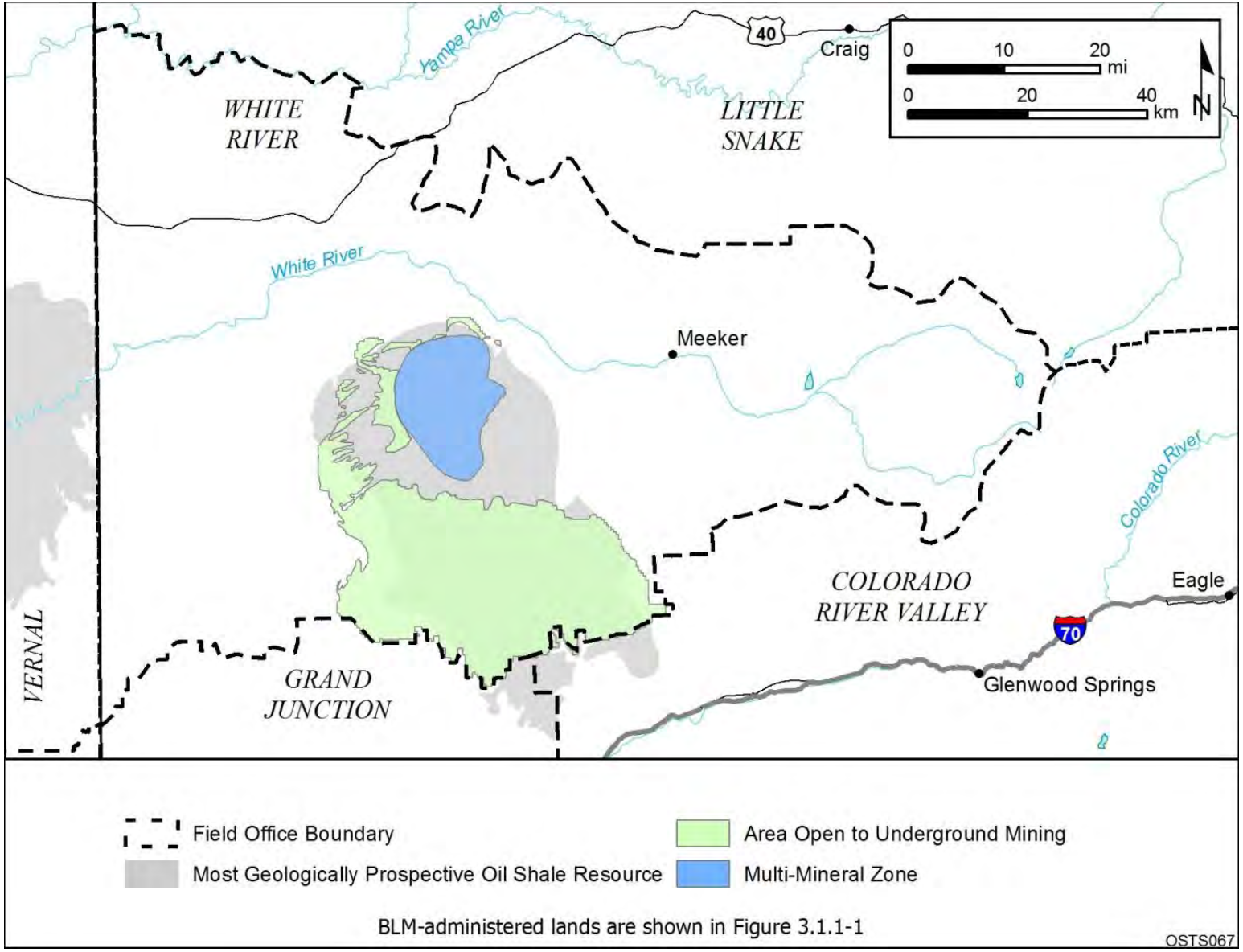

FIGURE 3.1.1-3 White River RMP Decisions Related to Oil Shale Leasing and Development

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 3.7.3.4 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, 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

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/Northwater Creek	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).

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, 85 federal oil and gas leases covering more than 136,000 acres, and 18 federal coal leases on about 52,800 acres, the BLM will verify whether “valid existing rights” are present on a case-by-case basis (BLM 1999a). This adjudication process to determine the valid existing rights for pending conversion leases in the Circle Cliffs STSA is currently under way.

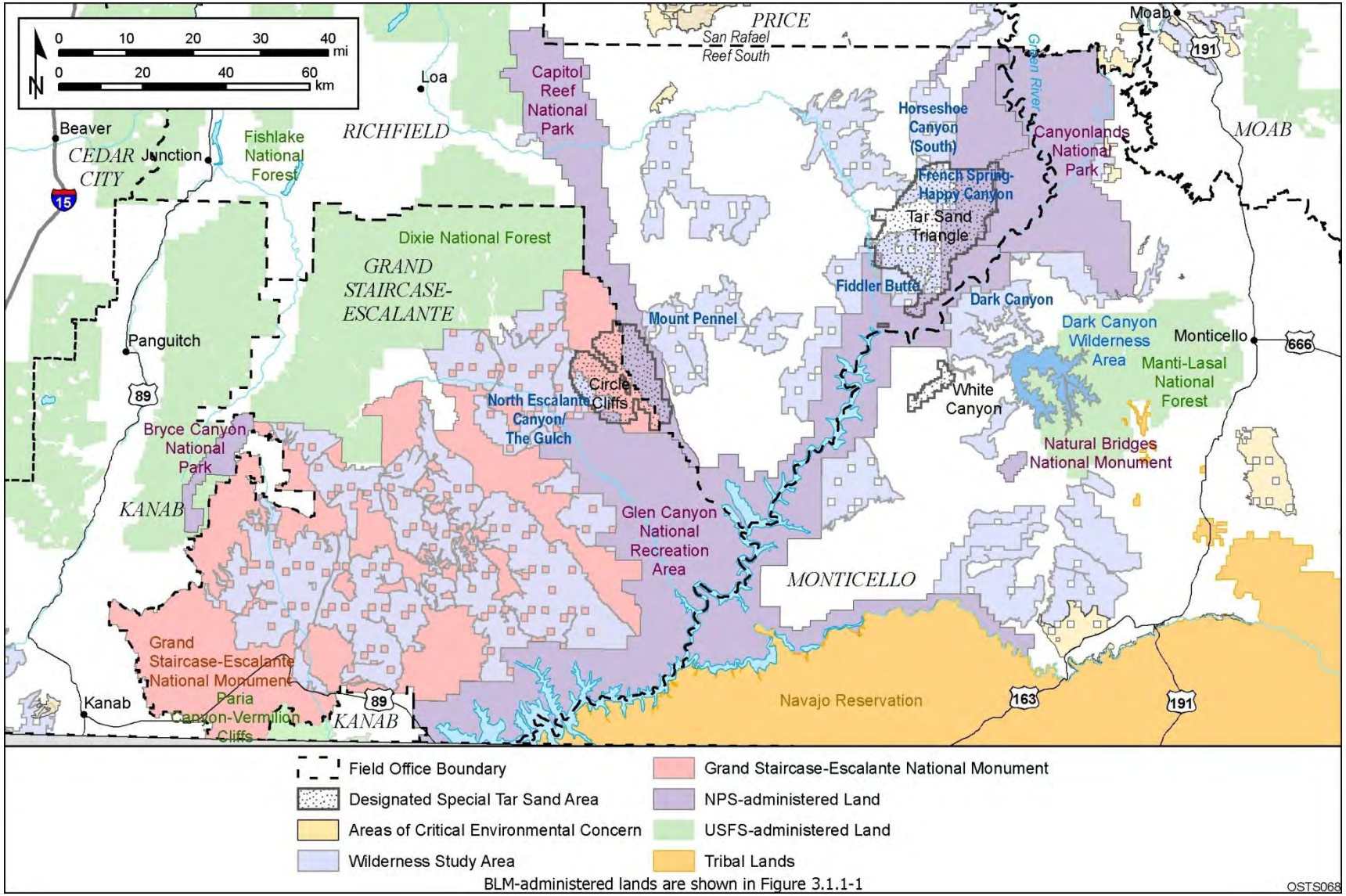

FIGURE 3.1.1-4 Portions of the Grand Staircase–Escalante National Monument and the Monticello and Richfield Field Offices Where Tar Sands Resources Are Located

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 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 (GCNRA) and Canyonlands National Park. The nearest boundary of the GCNRA 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 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,

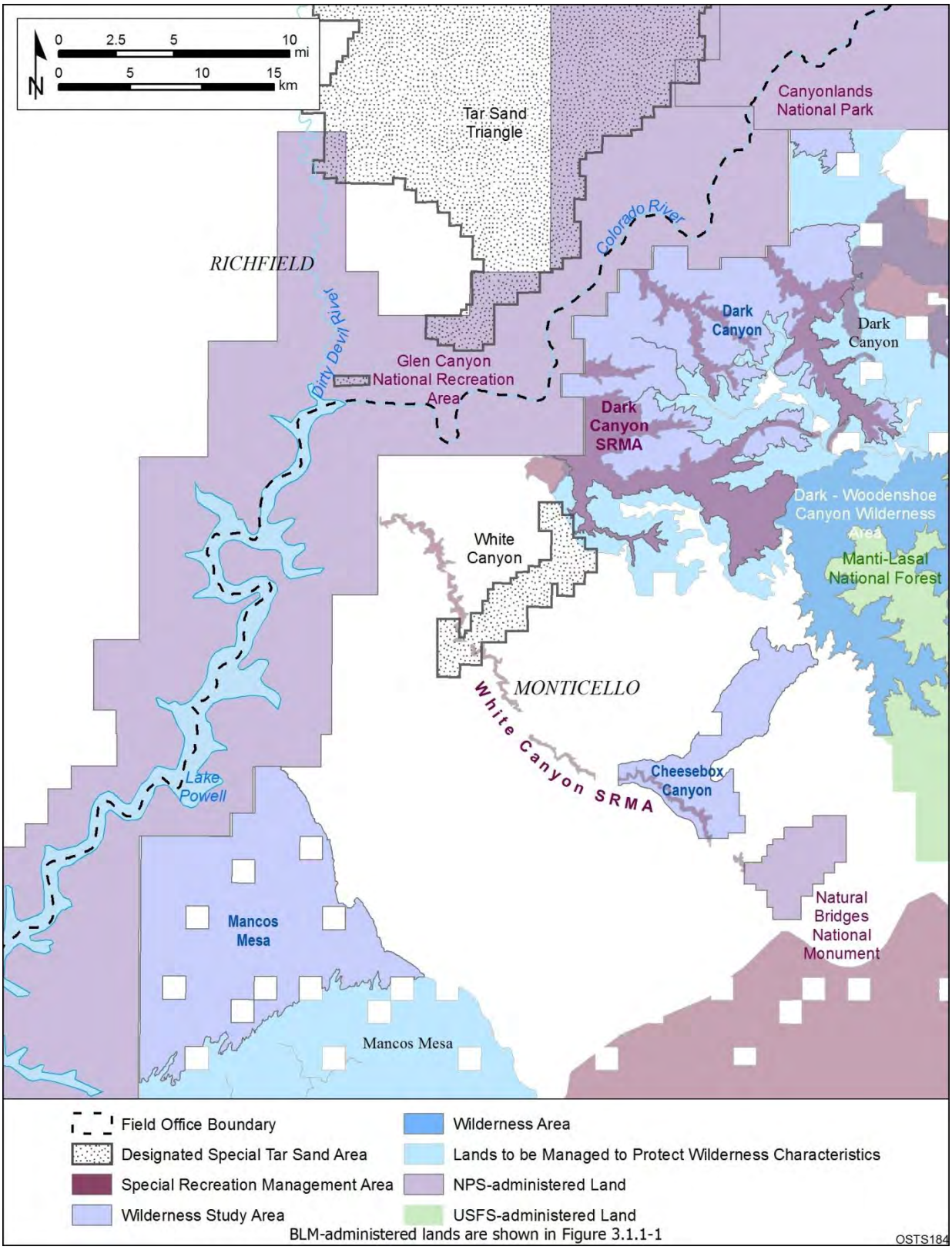

FIGURE 3.1.1-5 Specially Designated Areas in the Monticello Field Office in the Vicinity of the White Canyon STSA

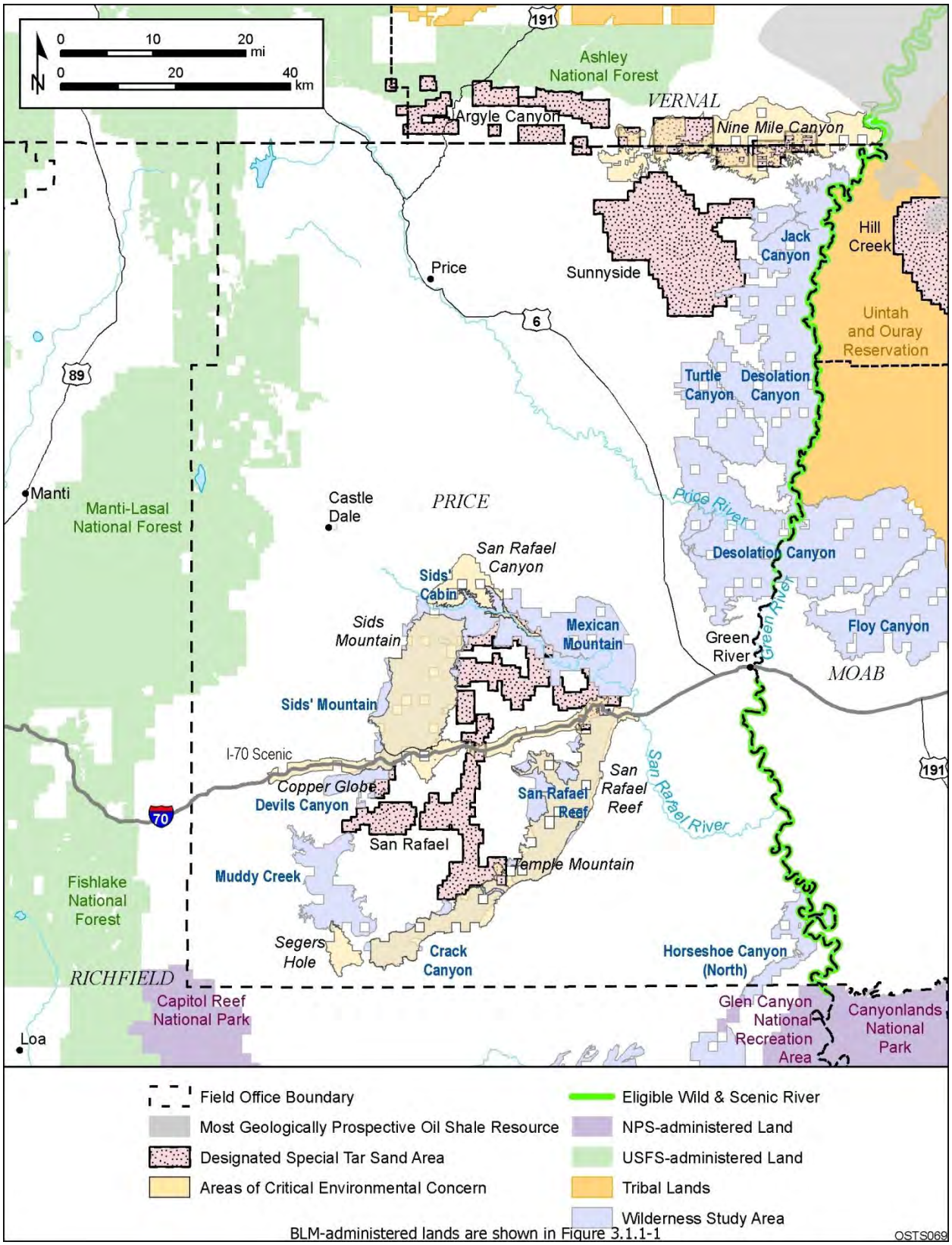

FIGURE 3.1.1-6 Price Field Office RMP Planning Area

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 3.7.3.4 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
Segers Hole	Scenic resources	0
Nine Mile Canyon	Cultural resources	22,335
San Rafael Reef ACEC	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.

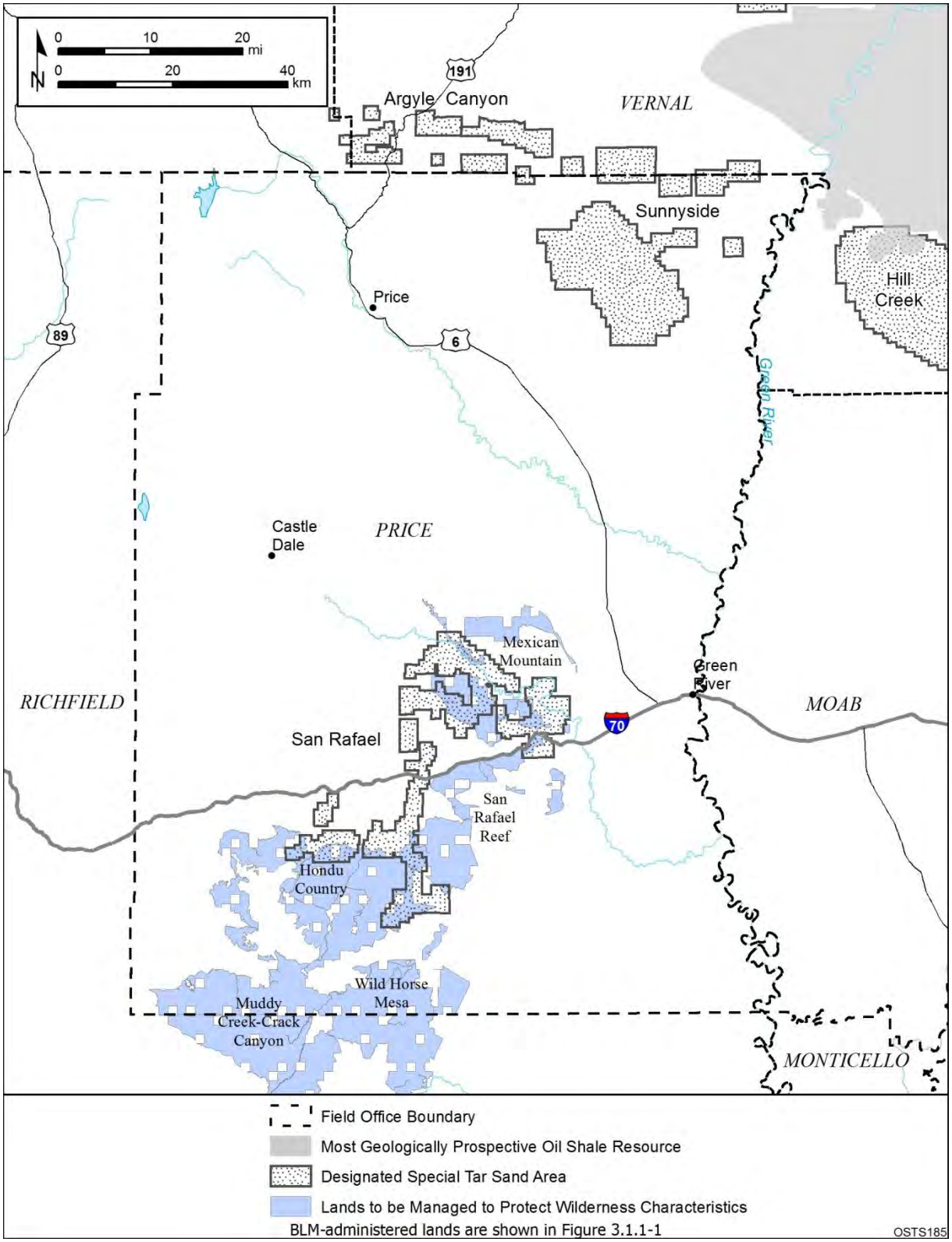

FIGURE 3.1.1-7 Areas with Wilderness Characteristics in the Price Field Office That the BLM Will Manage To Protect Those Characteristics That Overlap with Oil Shale and/or Tar Sands Deposits

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 3.7.3.4 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.

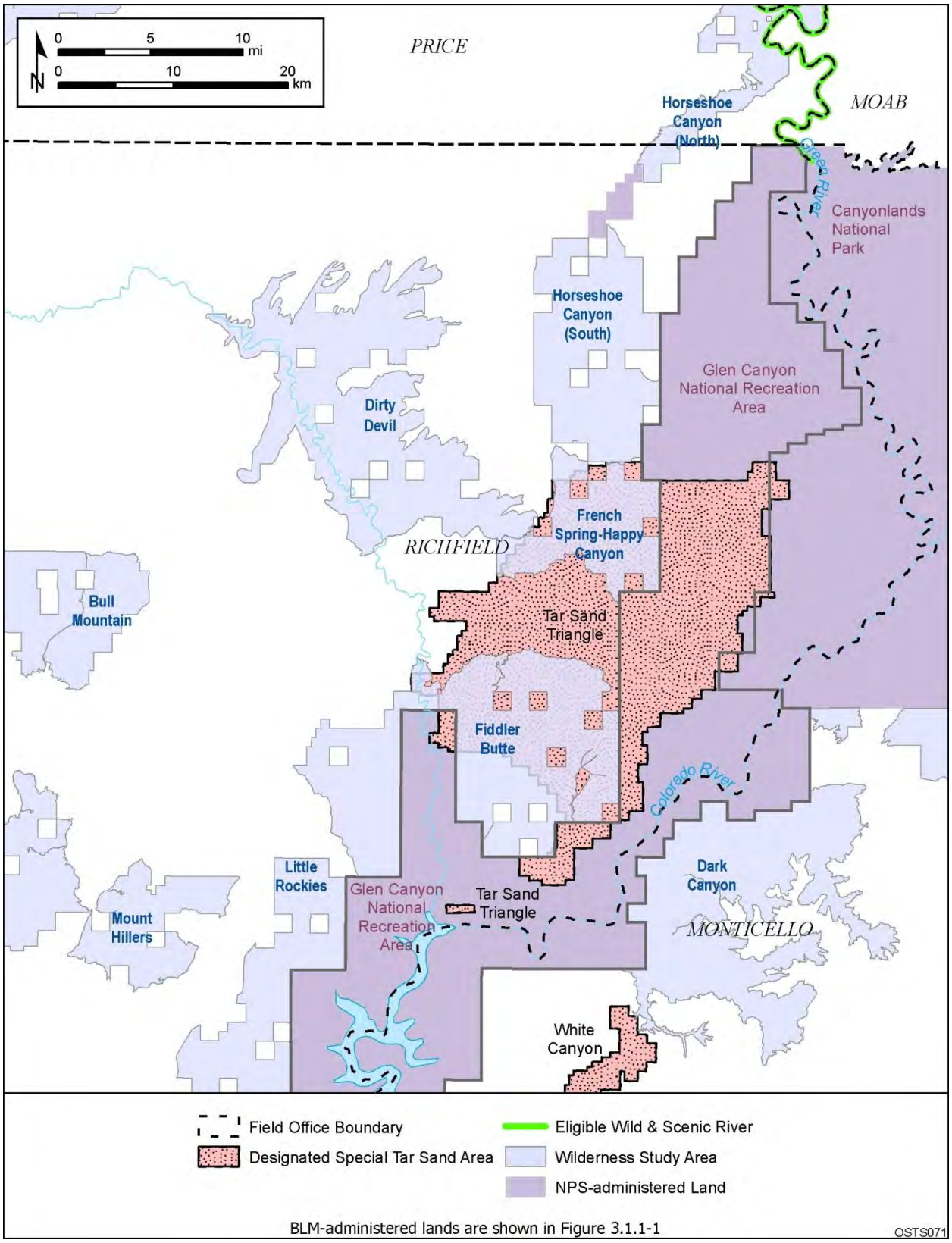

FIGURE 3.1.1-8 WSAs in the Richfield Field Office That Overlie the Tar Sand Triangle STSA

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 not 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.

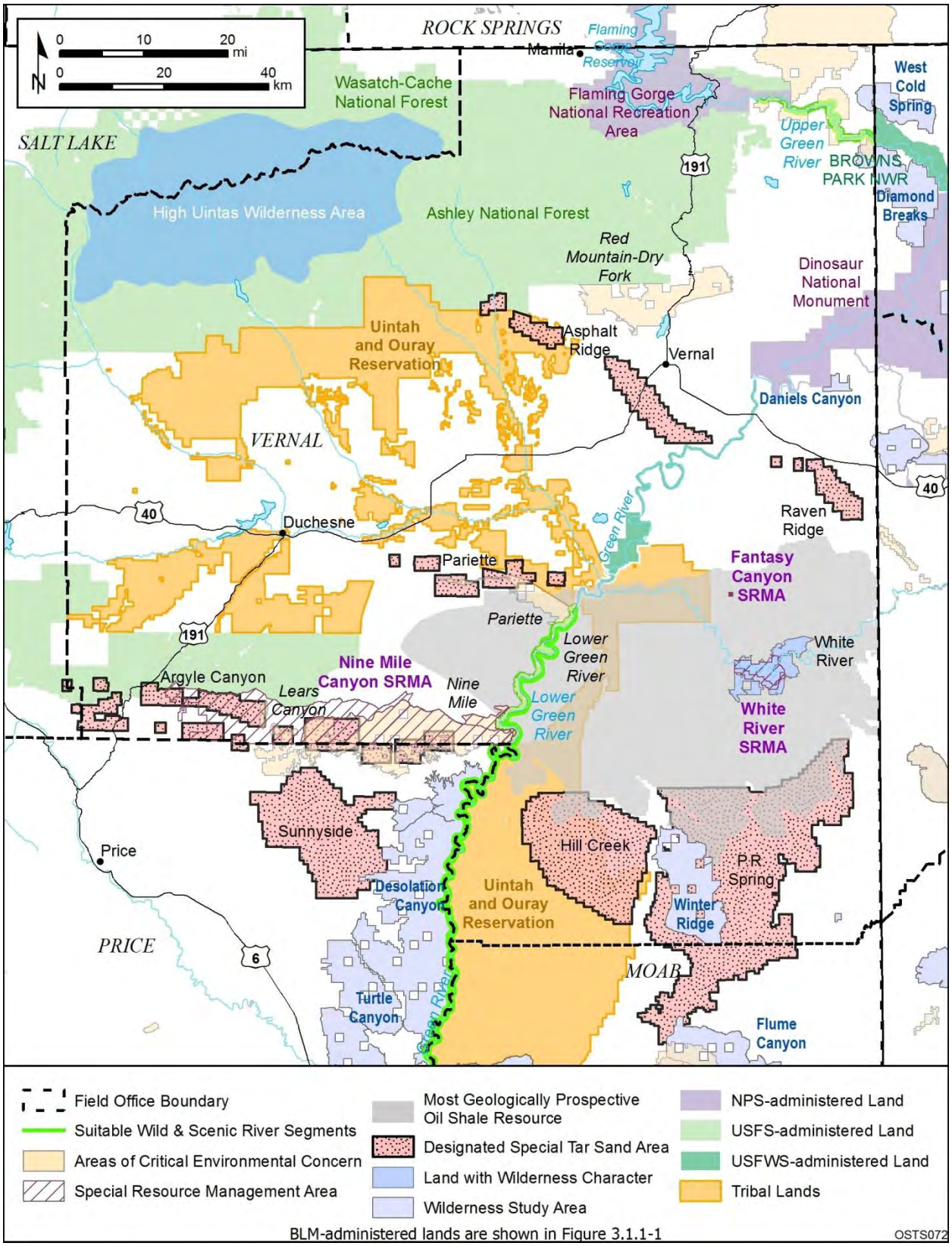

FIGURE 3.1.1-9 Vernal Field Office RMP Planning Area

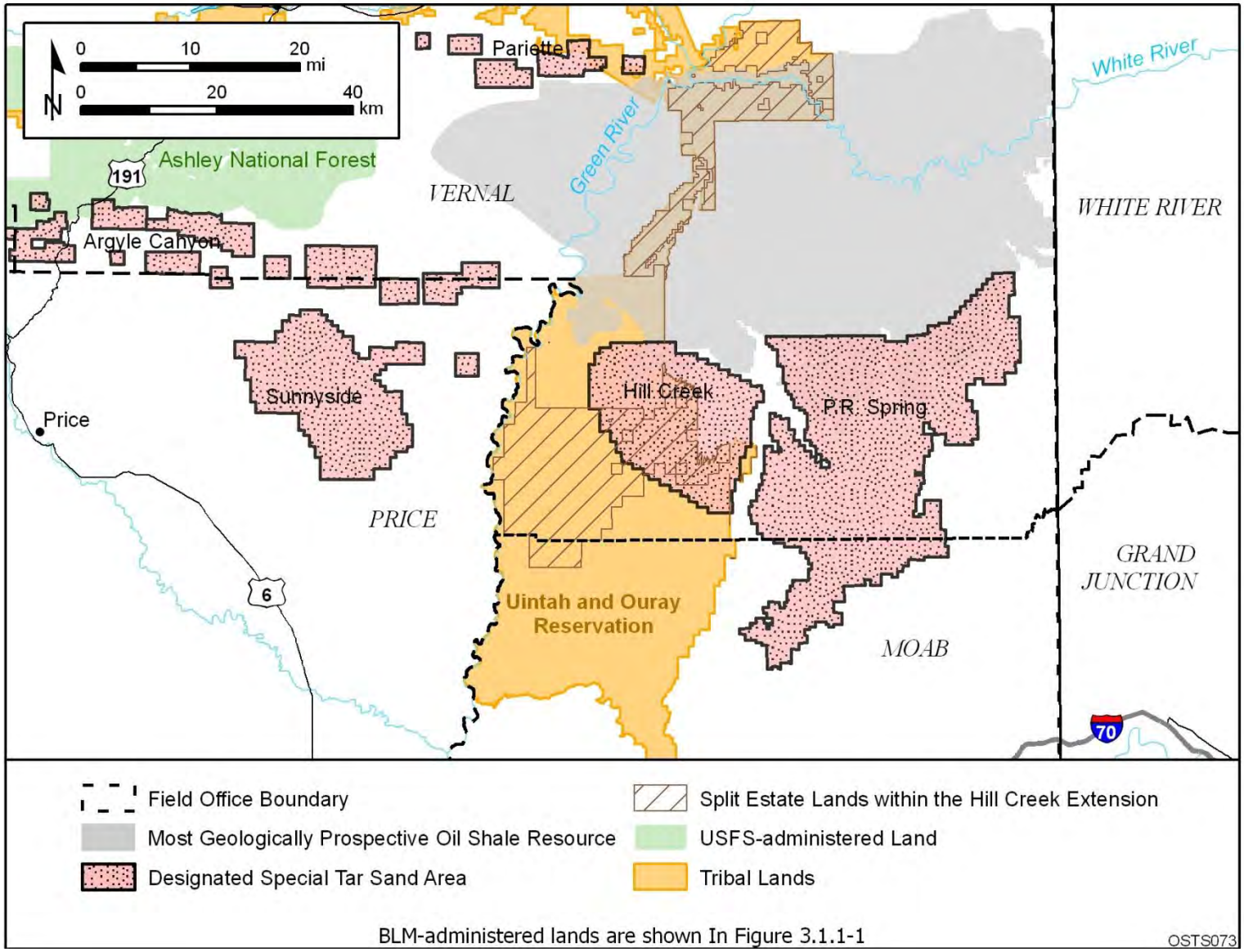

FIGURE 3.1.1-10 Split Estate Lands within the Hill Creek Extension of the Uintah and Ouray Reservation

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 2,800 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 six 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. The West Tavaputs Plateau development area overlaps with the Sunnyside and Argyle Canyon STSAs and some of the oil shale resources. 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

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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.

quantity of these deposits. In addition, lands covered by the oil shale withdrawal are not open to mining claims.

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 3.7.3.4 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 WSA 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[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.

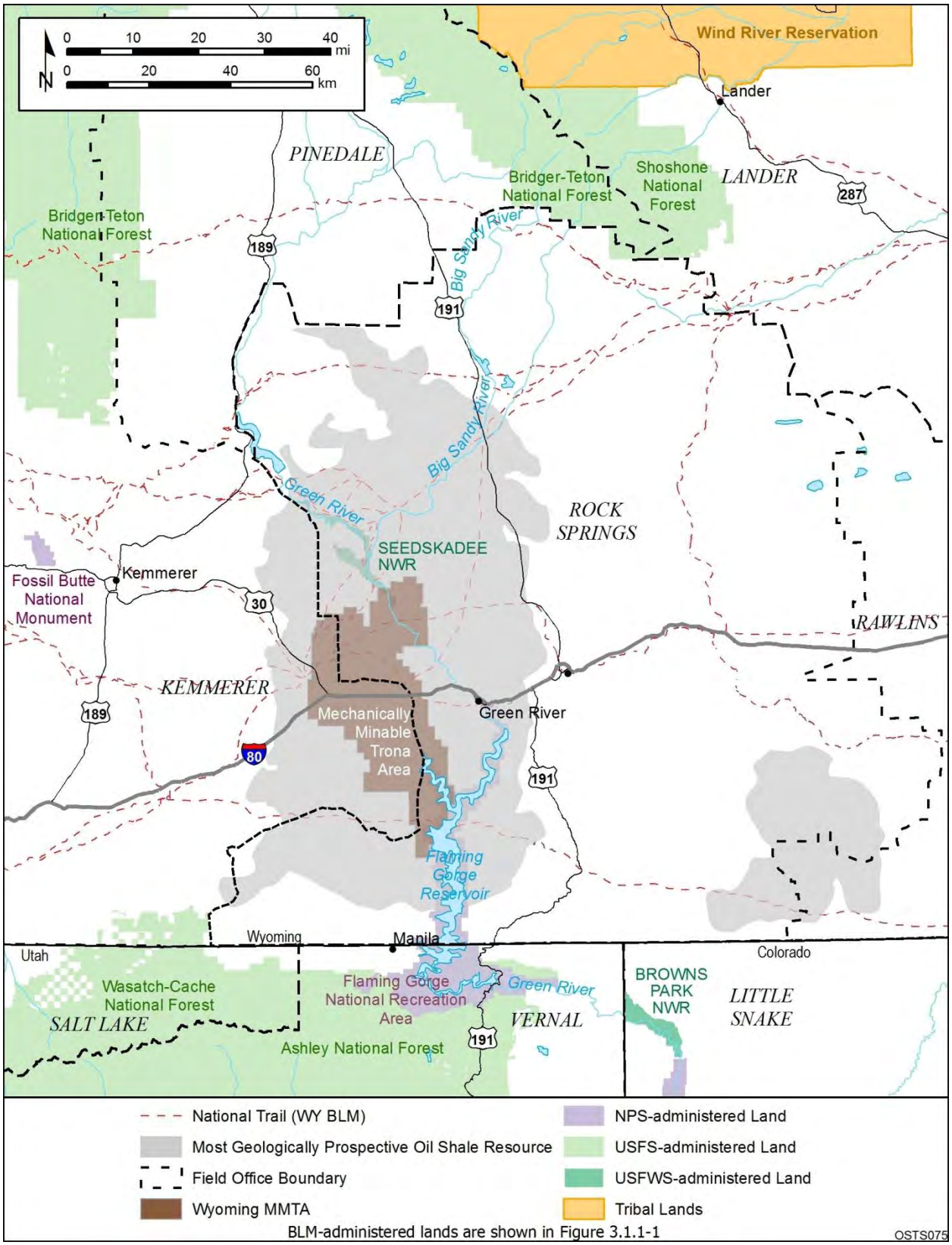

FIGURE 3.1.1-11 BLM Field Offices in Wyoming Where Oil Shale Resources Are Located

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 3.1.1-11). 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

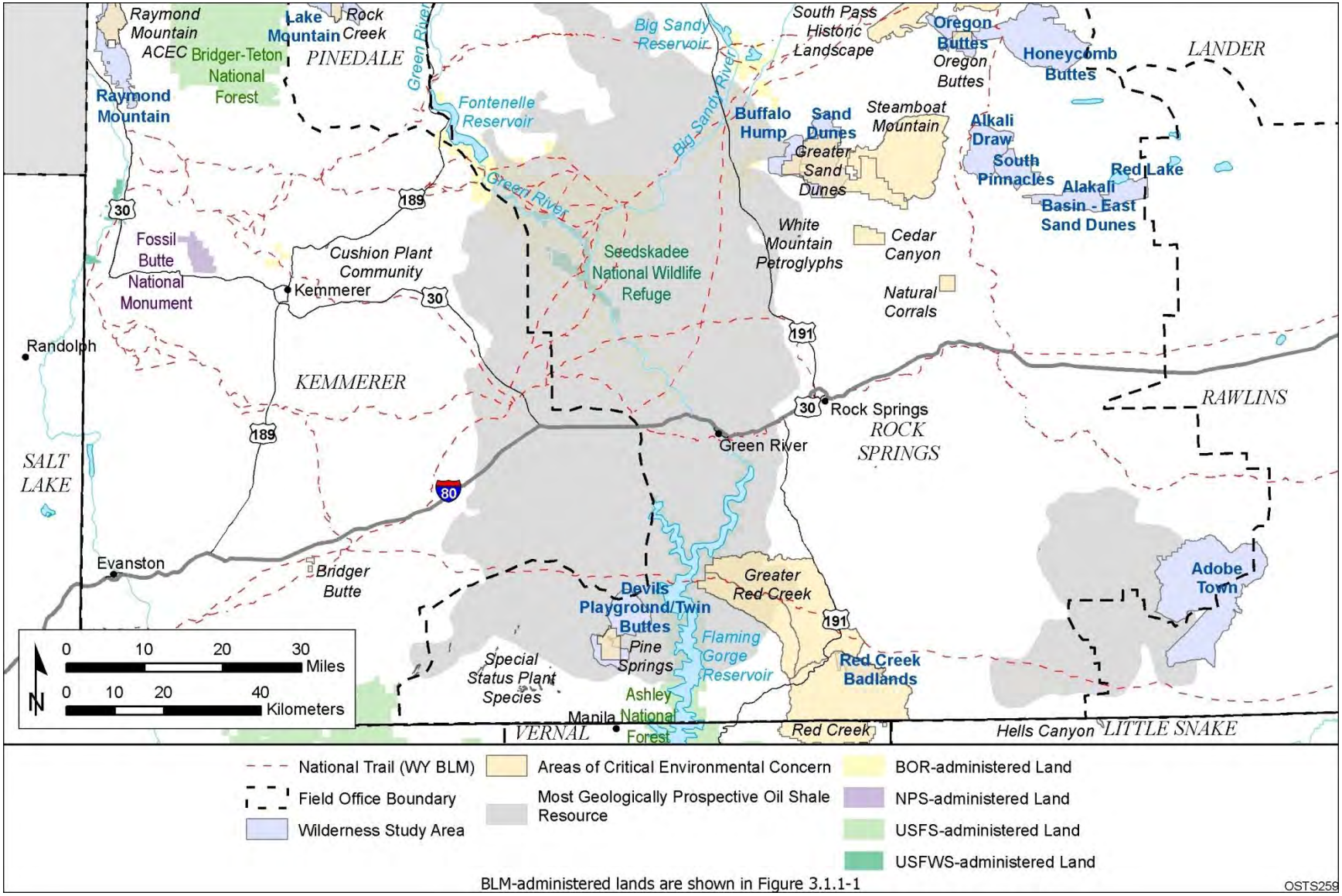

FIGURE 3.1.1-12 Specially Designated Areas in the Kemmerer Field Office

planning area encompassed by this RMP (Figure 3.1.1-11). The oil shale resources are located only 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 3.7.3.4 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). The WSA also sits within a larger area that was designated by the Wyoming Environmental Quality Council 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. Finally, these areas are located within a much larger area of land that has been identified as having wilderness characteristics. Table 3.1.1-7 presents the acreage overlapping the oil shale resource within the Adobe Town specially designated area and identified lands with wilderness characteristics. During the process of developing the Rawlins RMP, the BLM chose not to carry the analysis of wilderness characteristics into the Proposed RMP/Final EIS because valid existing lease rights prohibit management actions to protect the identified wilderness characteristics.

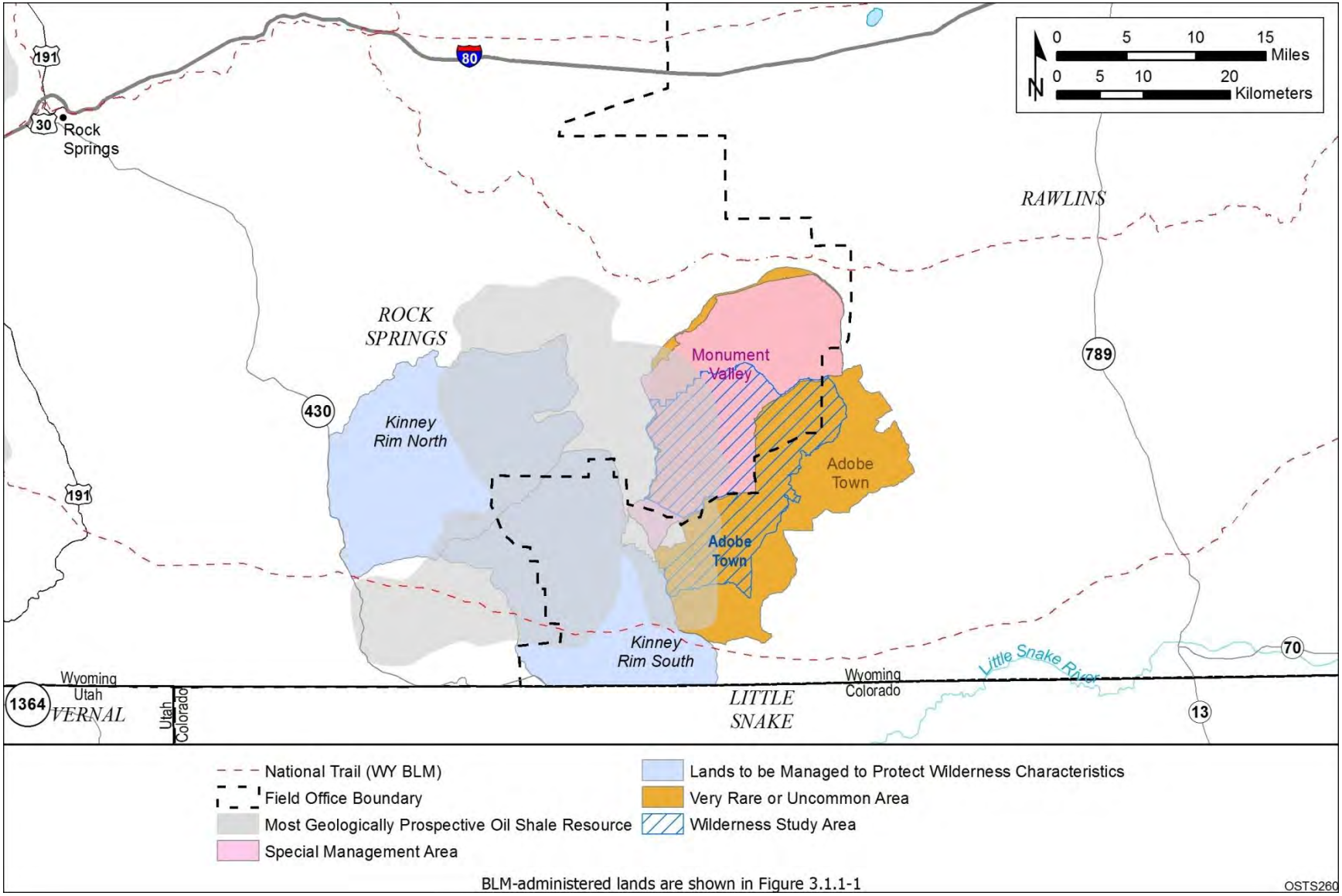

FIGURE 3.1.1-13 Specially Designated Areas in the Rawlins Field Office

TABLE 3.1.1-7 Rawlins Field Office LWCs and Adobe Town WSA and Very Rare or Uncommon Area That Overlap with Oil Shale Resources (only areas in Rawlins)

Area	R&I Criteria	Acreage[a]
Adobe Town WSA		54,330
Adobe Town Very Rare or Uncommon Area		96,183
Kinney Rim North LWC	NA	57,063
Kinney Rim South LWC	NA	77,392
Skull Creek LWC	NA	2,535

[a] Acreage estimates represent the portion overlying the oil shale resources and were derived from GIS data compiled to support the PEIS analyses.

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 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

Adobe Town, Little Colorado, Salt Wells Creek, and White Mountain Wild Horse HMAs overlap with some of the oil shale resources (see Section 3.7.3.4 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 four ACECs overlap oil shale resources in the Green River and Washakie Basins within the Rock Springs Field Office boundary, as shown in Figure 3.1.1-11 and listed in Table 3.1.1-8. 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 SMAs that have been designated either overlap or are adjacent to oil shale resources. The BLM has established stipulations restricting surface-disturbance activities within the two SMAs that overlap the oil shale resources being evaluated in this PEIS. Two areas outside of designated WSAs recognized by the BLM as having wilderness characteristics overlap with the most geologically prospective oil shale resources. Areas discussed in this paragraph are shown in Figure 3.1.1-14 and listed in Table 3.1.1-8.

In the southeastern part of the field office area, there are several special area designations that have been made and that overlap to varying degrees (see the discussion of the Adobe Town area in Section 3.1.1.10 above). In addition to the designations discussed above, within the Rock Springs Field Office area there is a designated SMA (Monument Valley) that almost completely overlaps the Adobe Town Very Rare or Uncommon Area designated by the Wyoming Environmental Council within the field office area. The SMA contains 98,308 acres that overlap oil shale resources in the Washakie Basin and the Very Rare and Uncommon Area contains 50,025 acres that overlap these resources (see Figure 3.1.1-11).

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. The BLM is not making allocation decisions for Forest Service–administered areas. 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 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.

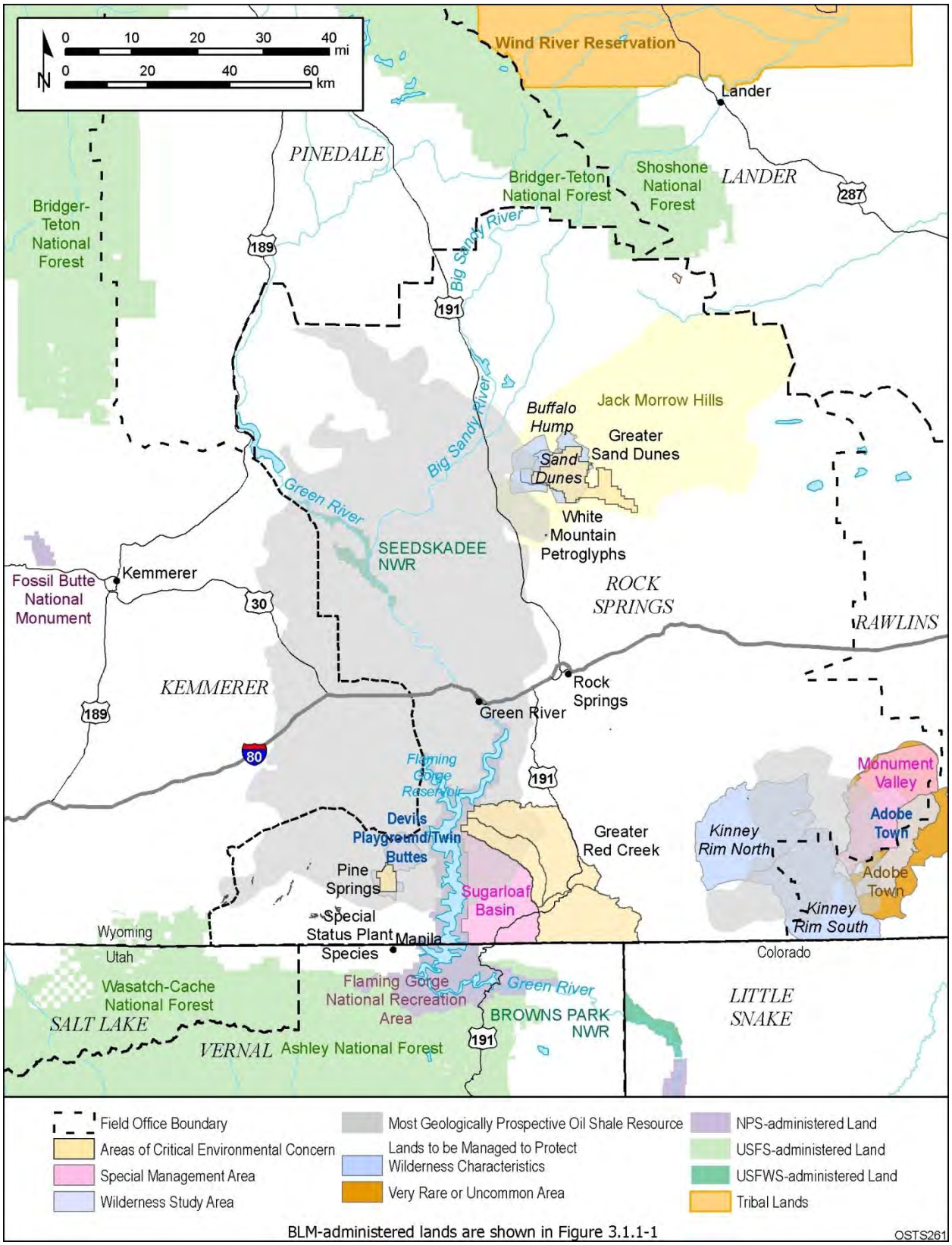

FIGURE 3.1.1-14 Specially Designated Areas in the Rock Springs Field Office

TABLE 3.1.1-8 Rock Springs Field Office LWCs, 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
Jack Morrow Hills Area 3	NA	233,350
Buffalo Hump LWC	NA	11,151
Kinney Rim North LWC	NA	57,063
Kinney Rim South LWC	NA	77,392
Sand Dunes LWC	NA	2,535

[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).

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.

3.2 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

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).

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 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.

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 is mainly by wind where overgrazing 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.

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

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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).

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.

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 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.

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

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[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.

1 **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.

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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).

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).

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, 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 in 1996, 1997, 1998, 2001, and 2004 to various salinity control projects under its Basinwide Salinity Control Program.

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 in the target oil shale basins and STSAs in 2006. In Colorado, no impaired streams are reported in the segments of the White River, Yampa River, and Green River Basins that are within oil shale leasing areas (CDPHE 2010). Impaired streams in the oil shale and tar sands areas in Utah have problems with meeting the total dissolved solids (TDS) water quality standard; Colorado and Wyoming do not have a TDS water quality standard. Streams in the Indian Canyon Creek subbasin also have elevated levels of selenium and boron. Fecal coliform is the major impairment in the Green River Basin in Wyoming; the source remains unknown.

TABLE 3.4.1-1 Water-Impaired Streams in Oil Shale Basins and STSAs in 2006

Hydrologic Basin	Subbasin	Hydrologic Unit Code	Stream	Location	Cause of Impairment
Oil Shale					
Colorado	No streams in the oil shale leasing areas of the White River/Yampa River/Green River hydrologic basin requiring TMDLs.				
Utah					
Uinta Basin	Duchesne River -1	UT14060003-001	Duchesne River and tributaries	Confluence Green River to Randlett	TDS
	Duchesne River -2	UT14060003-002	Duchesne River	Randlett to Myton	TDS
	Antelope Creek	UT14060003-005	Antelope Creek and tributaries	Confluence Duchesne River to headwaters	TDS
	Indian Canyon Creek	UT14060004-002	Indian Canyon Creek and tributaries	Confluence Strawberry River to headwaters	TDS
	Pariette Draw Creek	UT14060005-002	Pariette Draw Creek and tributaries	Confluence Green River to headwaters	Selenium, boron, and TDS
	Willow Creek	UT14060006-001	Willow Creek and tributaries	Confluence Green River to Meadow Creek confluence (excluding Hill Creek)	TDS
Wyoming					
Green River Basin	Blacks Fork Subbasin	14040107	Blacks Fork	From confluence with Ham's Fork upstream to an undetermined distance above Smiths Fork	Fecal coliform
			Smiths Fork	From confluence with Blacks Fork an undetermined distance upstream	Habitat degradation, fecal coliform
	Bitter Creek Subbasin	14040105	Bitter Creek	From Green River up to Killpecker Creek	Chloride, fecal coliform

TABLE 3.4.1-1 (Cont.)

Hydrologic Basin	Subbasin	Hydrologic Unit Code	Stream	Location	Cause of Impairment
Special Tar Sand Areas (only with impaired streams are listed)					
Utah (in Uinta Basin)					
P.R. Spring	Willow Creek	UT14060006-001	Willow Creek and tributaries	Confluence Green River to Meadow Creek confluence (excluding Hill Creek)	TDS
Hill Creek	Willow Creek	UT14060006-001	Willow Creek and tributaries	Confluence Green River to Meadow Creek confluence (excluding Hill Creek)	TDS
Pariette	Pariette Draw Creek	UT14060005-002	Pariette Draw Creek and tributaries	Confluence Green River to headwaters	Selenium, boron, and TDS
Sunnyside	Nine Mile	UT14060005-003	Nine Mile Creek and tributaries	Confluence Green River to headwaters	Temperature
Argyle Canyon	Indian Canyon Creek	UT14060004-002	Indian Canyon Creek and tributaries	Confluence Strawberry River to headwaters	TDS
	Antelope Creek	UT14060003-005	Antelope Creek and tributaries	Confluence Duchesne River to headwaters	TDS

Sources: WDEQ (2006); CDPHE (2006); UDEQ (2007).

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 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 and the water consumption 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).

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

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

Location	Demand (ac-ft/yr)			Consumptive Use (ac-ft/yr)		
		2030[a]			2030[a]	
	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.)

[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

	Demand (ac-ft/yr)			Consumptive Use (ac-ft/yr)		
Location	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

Location	Demand (ac-ft/yr) 2000	2030[a] Low	2030[a] Moderate	2030[a] High	Consumptive Use[b] (ac-ft/yr) 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).

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 (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.

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. A comparison of the 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

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

Locations	1,000 ac-ft/yr			
	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).

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.

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 two aquifers and two 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 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 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). 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 1,000 to

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.

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. The minimum and maximum recorded flows below the town of Meeker are 78 cubic feet per second (cfs) (in 1977) and 6,950 cfs (in 1984), respectively. The average discharge based on records from 1910 to 2006 near the town of Meeker is 620 cfs (USGS 2006a). 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).

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

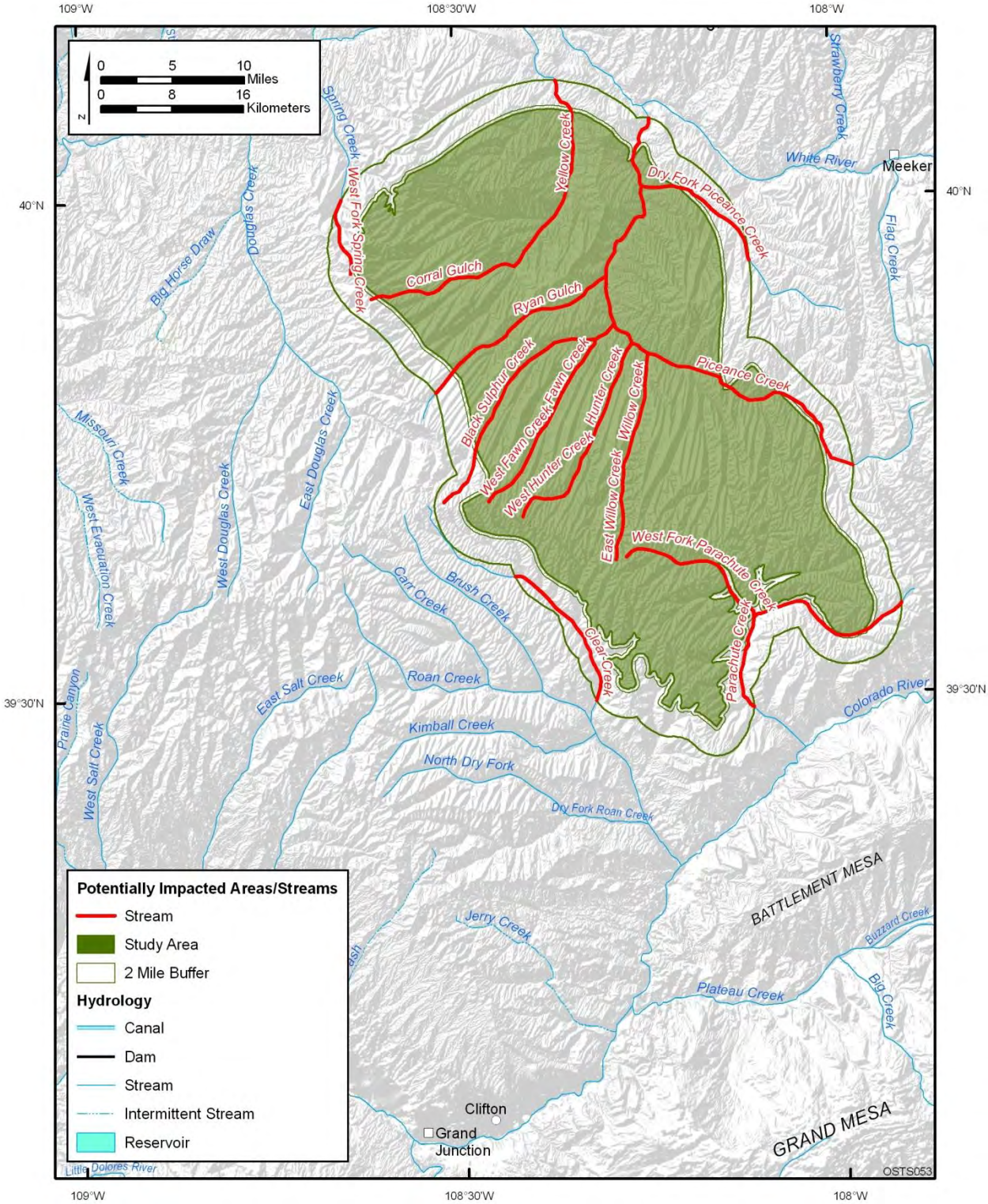

FIGURE 3.4.2-1 Yellow and Piceance Creeks and Their Tributaries in the Piceance Basin

maximum peak streamflow is much higher at 39,300 cfs. During low-flow seasons, groundwater discharge contributes part of the streamflow (Tobin 1987).

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 (Utah DNR 2000).

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.

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).

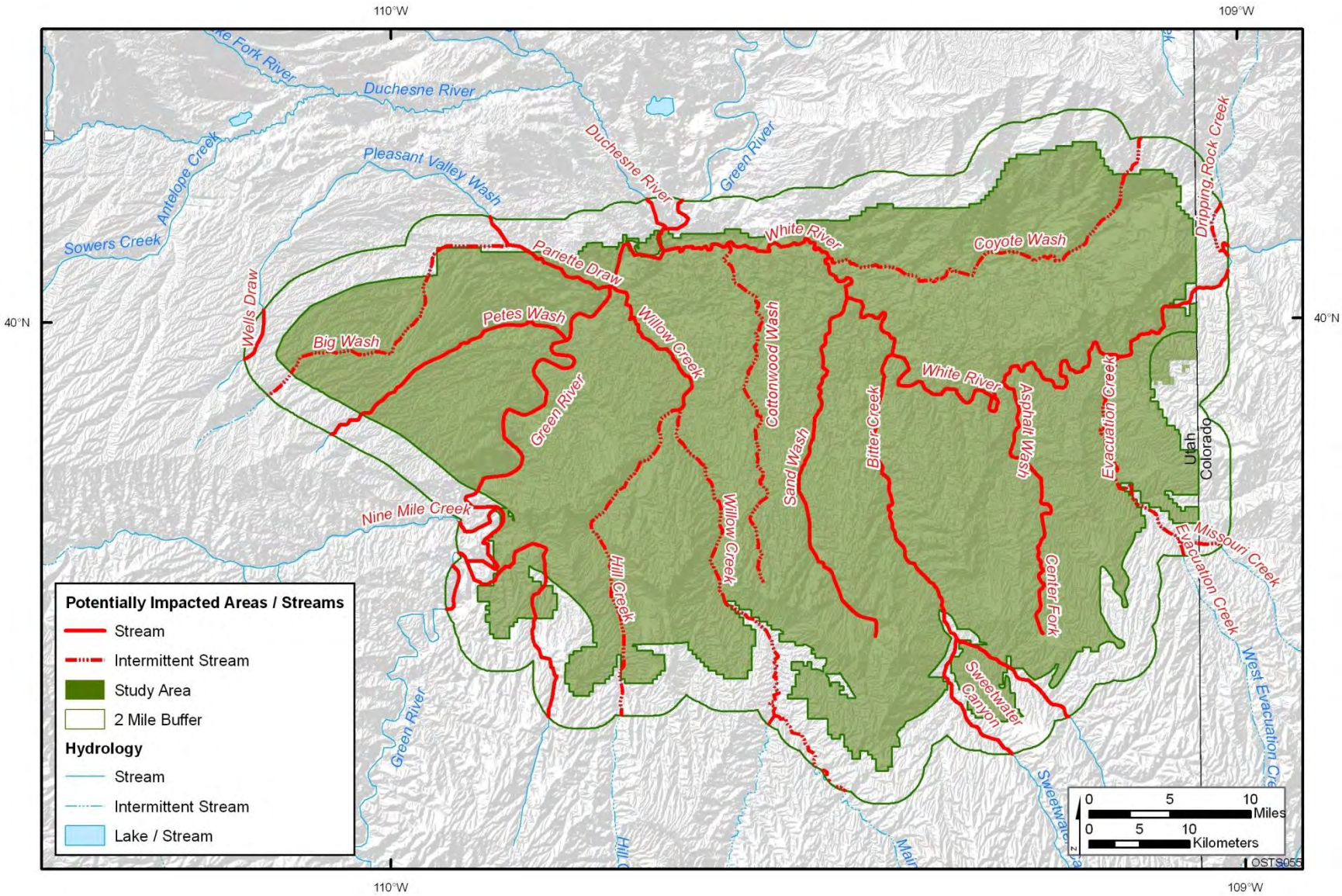

FIGURE 3.4.3-1 Major Rivers and Their Tributaries in the Uinta Basin

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 Miller and Mason (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. Miller and Mason (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, Miller and Mason (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).

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

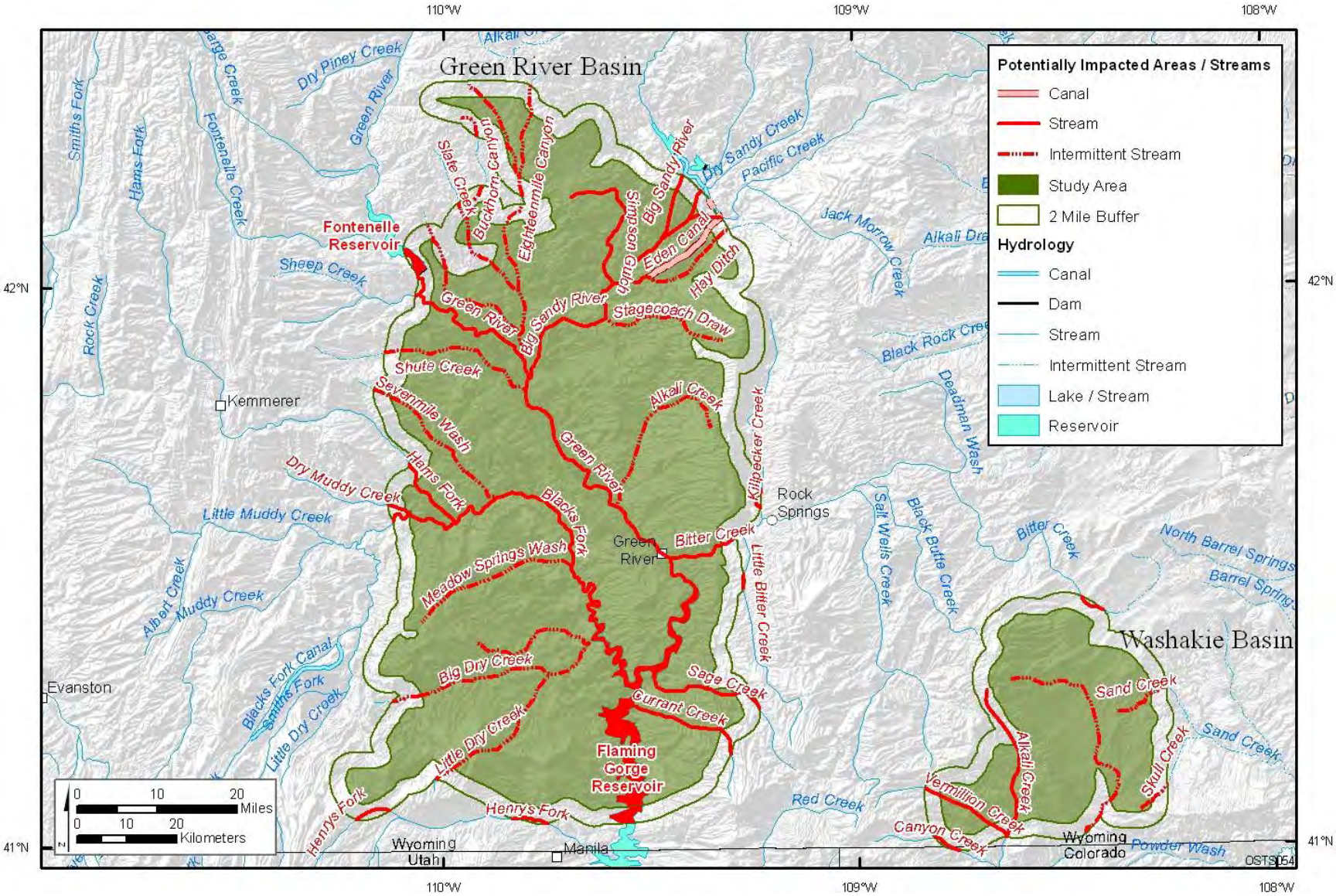

FIGURE 3.4.4-1 Major Rivers and Their Tributaries in the Green River and Washakie Basins

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.

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).

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).

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

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

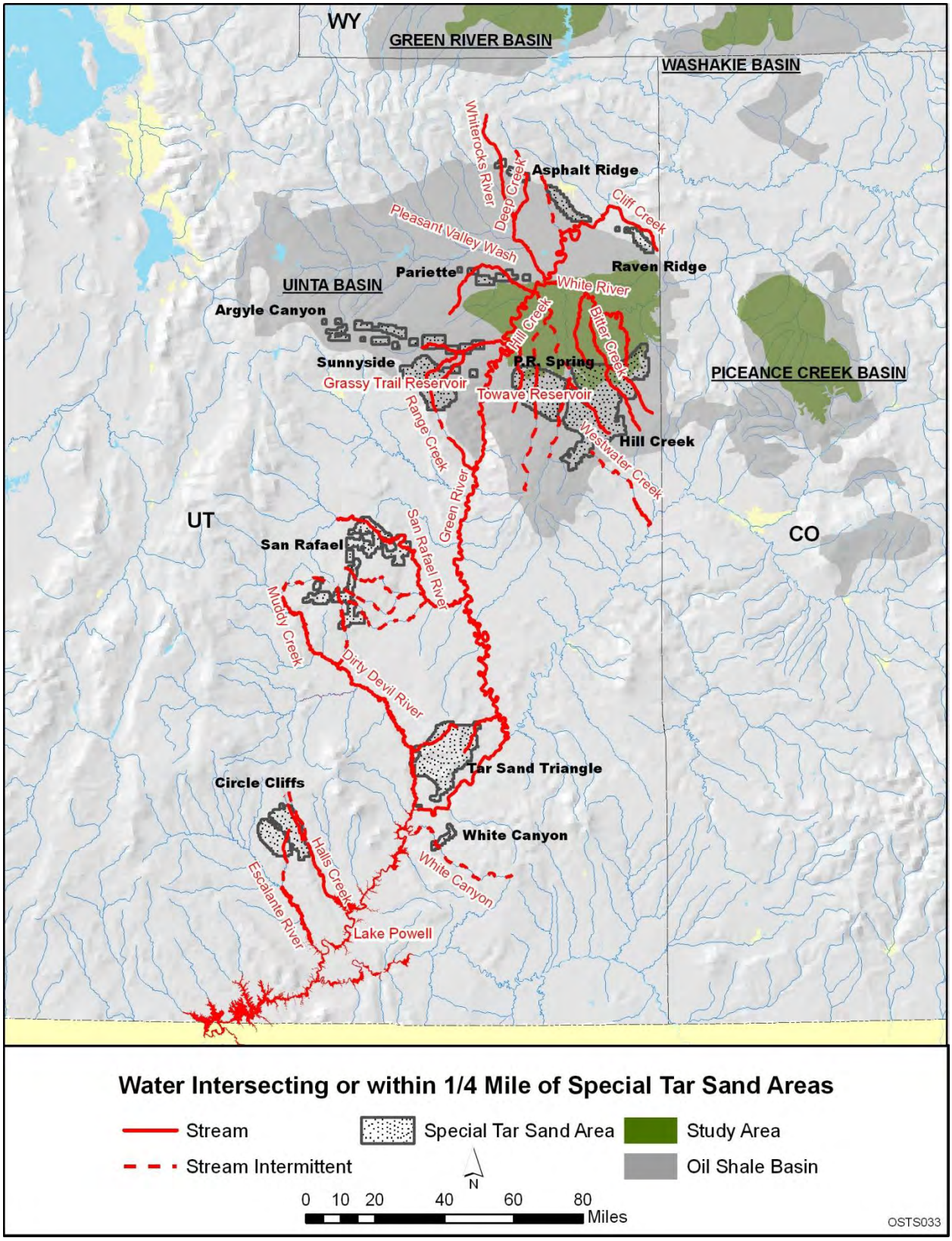

FIGURE 3.4.5-1 Green River and Dirty Devil River Basins Drainage Map

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

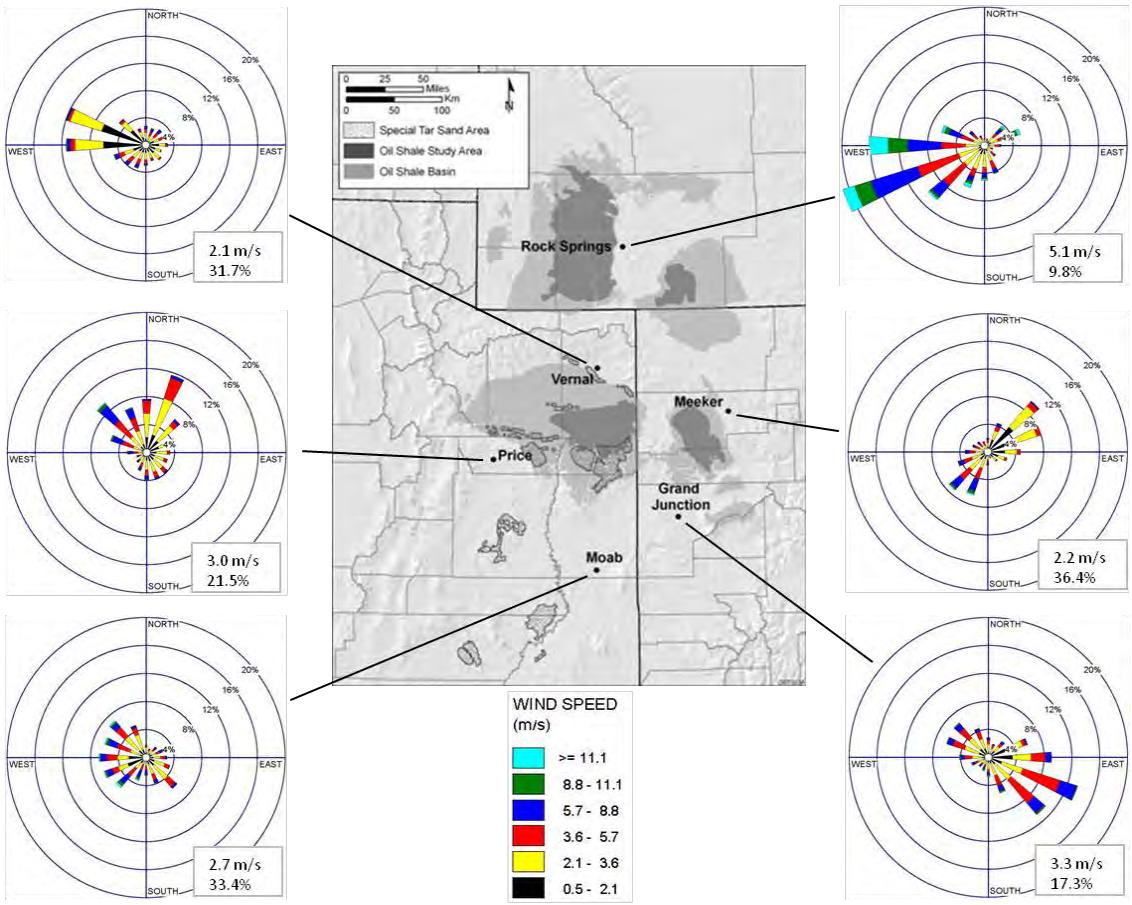

FIGURE 3.5.1-1 Wind Roses at the 33-ft Level for Selected Meteorological Stations around the Study Area, 2006–2010 (Source: NCDC 2011a) (Note that the first and second values in the lower-right corner of each wind rose denote the average wind speed [m/s] and calm wind frequency [%], respectively.)

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 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.

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

			Temperature (°F)[a]			Precipitation (in.)		
Station	State	County	Average Monthly Minimum	Average Monthly Maximum	Mean[b]	Total Water Equivalent	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).

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

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[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.

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. 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 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

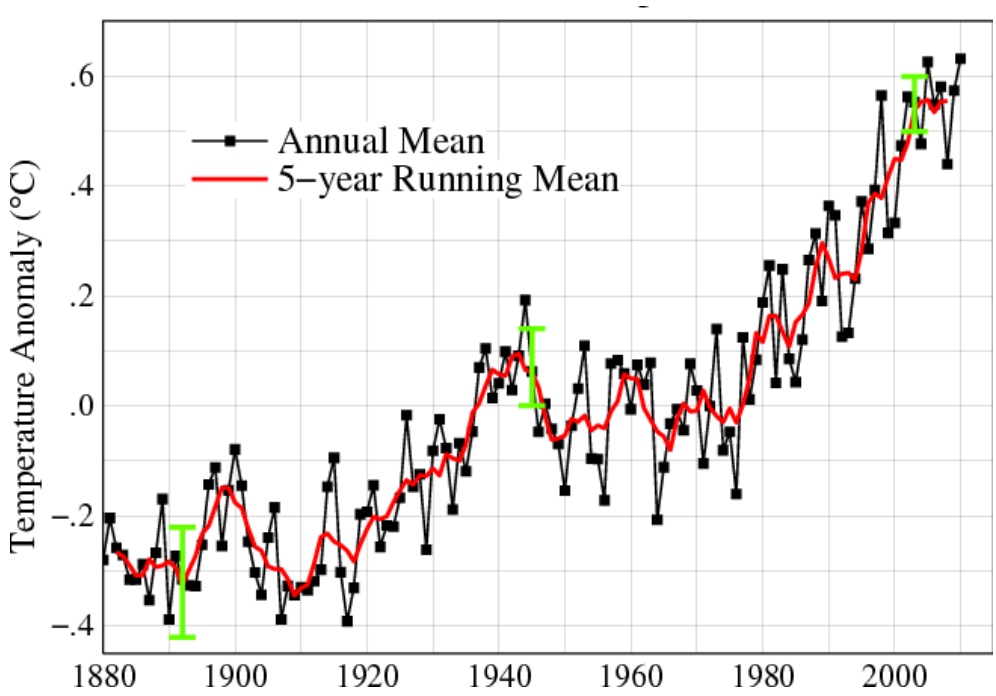

FIGURE 3.5.1-2 Global Mean Land-Ocean Temperature Index, 1880 to Present, with Base Period 1951–1980 (Source: GISS 2011)

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.

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. Within the three-state area, fire activity is predicted to increase between 73% and 515%.

- 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 2002 for counties within and around the study area in Colorado, Utah, and Wyoming (WRAP 2006). The emission inventory is based on six categories: area, biogenic, fire, nonroad, onroad, and point air pollutant emission sources, including existing transportation, mining, manufacturing, and oil and gas emission sources.

In Colorado, fire, including wildfire, prescribed fire, and agricultural burning, was a primary contributor to total emissions of carbon monoxide (CO) and particulate matter (PM_{10}

TABLE 3.5.2-1 Annual Air Pollutant Emissions for Counties within and around the Study Area, 2002

		County Contains:		Emission Rate (tons/yr)					
State	County	Oil Shale	Tar Sands	SO_x	NO_x	CO	VOC	PM_{10}	$PM_{2.5}$
Colorado	Chaffee	No	No	125	1,009	11,931	17,286	850	321
	Delta	Yes	No	107	1,800	17,276	25,417	1,785	723
	Dolores	No	No	10	854	5,330	21,228	866	207
	Eagle	No	No	201	4,901	44,646	24,212	2,396	884
	Garfield	Yes[a]	No	1,749	15,937	293,869	67,861	26,434	21,641
	Grand	No	No	130	2,007	15,170	25,268	1,455	391
	Gunnison	No	No	69	1,311	20,044	36,498	1,534	778
	Jackson	No	No	17	574	6,108	28,565	259	140
	La Plata	No	No	923	8,870	154,403	38,107	15,062	12,152
	Lake	No	No	57	2,027	25,328	10,824	668	217
	Mesa	Yes	No	2,441	7,813	61,436	52,093	5,417	1,683
	Moffat	Yes	No	10,781	23,563	75,183	47,140	8,530	5,116
	Montezuma	No	No	98	2,328	23,540	35,141	1,518	724
	Montrose	No	No	1,606	3,225	22,456	30,354	3,568	1,136
	Pitkin	No	No	67	1,134	13,352	19,902	456	199
	Rio Blanco	Yes[a]	No	325	7,100	61,452	51,235	5,283	4,113
	Routt	No	No	4,075	14,610	202,581	48,283	20,677	15,989
	San Miguel	No	No	902	4,152	156,094	25,826	15,006	12,573
	Subtotal			23,683	103,215	1,210,199	605,240	111,764	78,987
Utah	Carbon	Yes[a]	Yes	8,218	7,540	40,095	28,722	2,484	1,665
	Daggett	Yes	No	318	2,288	55,378	21,731	5,122	4,323
	Emery	Yes	Yes	21,126	34,110	35,385	49,557	3,618	1,583
	Garfield	No	Yes	296	1,643	45,902	68,986	3,158	2,449
	Grand	Yes	Yes	913	6,076	160,774	61,092	13,680	11,595
	Juab	No	No	338	4,934	61,703	41,426	1,272	462
	Kane	No	No	106	999	19,289	74,159	374	182
	Piute	No	No	93	483	15,443	18,492	1,065	756
	San Juan	No	Yes	1,780	3,681	57,213	101,074	3,989	2,641
	Sanpete	No	No	512	1,853	25,230	28,421	1,885	805

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}	$PM_{2.5}$
Utah (Cont.)	Sevier	No	No	633	3,002	49,156	29,446	3,197	2,018
	Uintah	Yes[a]	Yes	1,192	11,915	30,010	73,930	2,735	1,559
	Wayne	No	Yes	162	469	8,778	35,508	341	72
	Subtotal			35,687	78,993	604,356	632,544	42,920	30,110
Wyoming	Carbon	Yes	No	4,362	13,614	32,885	81,356	2,370	832
	Fremont	Yes	No	5,221	7,925	153,615	80,085	14,020	11,047
	Lincoln	Yes[a]	No	22,688	21,842	47,089	51,473	6,309	3,568
	Sublette	Yes[a]	No	867	8,710	57,450	87,025	4,844	3,858
	Sweetwater	Yes[a]	No	35,107	65,380	71,694	104,410	19,140	7,269
	Uinta	Yes[a]	No	7,470	9,066	22,196	25,983	1,530	588
	Subtotal			75,715	126,537	384,929	430,332	48,213	27,162
Region	Total			135,085	308,745	2,199,484	1,668,116	202,897	136,259

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

Source: WRAP (2006).

and $PM_{2.5}$ [particulate matter with a mean aerodynamic diameter of 10 μm or less, or 2.5 μm or less, respectively]). Stationary "point" sources accounted for about 72% of the sulfur oxides (SO_x) emissions and 41% of the nitrogen oxides (NO_x) emissions. "Biogenic" sources (e.g., naturally occurring emissions from vegetation, including trees, plants, and crops) accounted for most of the VOC emissions. "Onroad" sources and "area" sources were secondary contributors to NO_x and CO emissions and PM_{10} and $PM_{2.5}$ emissions, respectively. "Nonroad" sources were minor contributors to all pollutants in Colorado. For Utah and Wyoming, primary and secondary contributors were the same as and similar to, respectively, those for Colorado, although the levels of emissions were somewhat different.

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 2011b). 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 2011). In Utah, the standards are equivalent to the NAAQS for each pollutant (UDEQ 2011). 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 (WDEQ 2011).

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 2011c). One exception is Utah County, in which a minute portion of tar sands resources are located in the southeastern corner, 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.

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

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

		NAAQS[b]		SAAQS			PSD Increment ($\mu g/m^3$)[f]	
Pollutant[a]	Averaging Time	Standard Value	Standard Type[c]	Colorado	Utah[d]	Wyoming[e]	Class I	Class II
SO_2	1 h	75 ppb	P	–[g]	75 ppb	–	–	–
	3 h	0.5 ppm	S	700 $\mu g/m^3$ (0.267 ppm)	0.5 ppm	1,300 $\mu g/m^3$ (0.50 ppm)	25	512
	24 h	0.14 ppm (1971 standard)	P	–	0.14 ppm (1971 standard)	260 $\mu g/m^3$ (0.10 ppm)	5	91
	Annual	0.03 ppm (1971 standard)	P	–	0.03 ppm (1971 standard)	60 $\mu g/m^3$ (0.02 ppm)	2	20
NO_2	1 h	100 ppb	P	–	100 ppb	–	–	–
	Annual	53 ppb	P, S	–	53 ppb	100 $\mu g/m^3$ (0.05 ppm)	2.5	25
CO	1 h	35 ppm (40 mg/m^3)	P	–	35 ppm (40 mg/m^3)	40 mg/m^3 (35 ppm)	–	–
	8 h	9 ppm (10 mg/m^3)	P	–	9 ppm (10 mg/m^3)	10 mg/m^3 (9 ppm)	–	–
O_3[h]	8 h	0.08 ppm (1997 standard)	P, S	–	0.08 ppm (1997 standard)	0.08 ppm	–	–
		0.075 ppm (2008 standard)	P, S	–	0.075 ppm (2008 standard)	–	–	–
PM_{10}	24 h	150 $\mu g/m^3$	P, S	–	150 $\mu g/m^3$	150 $\mu g/m^3$	8	30
	Annual	–[i]	–	–	–	50 $\mu g/m^3$	4	17
$PM_{2.5}$	24 h	35 $\mu g/m^3$	P, S	–	35 $\mu g/m^3$	35 $\mu g/m^3$	2	9
	Annual	15.0 $\mu g/m^3$	P, S	–	15.0 $\mu g/m^3$	15 $\mu g/m^3$	1	4
Pb	Rolling 3 mo	0.15 $\mu g/m^3$	P, S	–	0.15 $\mu g/m$	0.15 $\mu g/m^3$	–	–

Footnotes on next page.

TABLE 3.5.3-1 (Cont.)

[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 (2011b) 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] A dash indicates that no standard exists.

[h] EPA revoked the 1-hour ozone standard in most areas of the United States, including all portions of the study area. Consequently, the 1-hour ozone standard is not discussed further in this document.

[i] Because of a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the EPA revoked the annual PM_{10} standard, effective December 18, 2006 (71 FR 61144).

Sources: 40 CFR Part 50; 40 CFR 52.21; 75 FR 64864; CDPHE (2011); EPA (2011b); UDEQ (2011); WDEQ (2011).

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 with the second highest of 0.122 ppm in February 2008 (EPA 2011d). 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

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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.

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 2010).

[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 (2011d).

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 miles north-northwest of Evanston in Uinta, County, Wyoming.

Source: EPA (2011d).

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 2011d).

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 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

[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.

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.

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.

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]).

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 2011e). 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:

- 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.[13] 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 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.

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[13] 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.

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 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;

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=.

for example, Duchesne County, Utah, limits construction and mining activities to daytime and evening hours.

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 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 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.

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).

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, 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).

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 20–60 years; Belnap and Campbell 2011);
- A reduction in runoff (6–20% decrease by 2050 in the upper Colorado River Basin; Ray et al. 2008);
- A reduction in stream flow (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 (10–20% 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 stream flow 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 stream flow 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 WFGD 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 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.

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

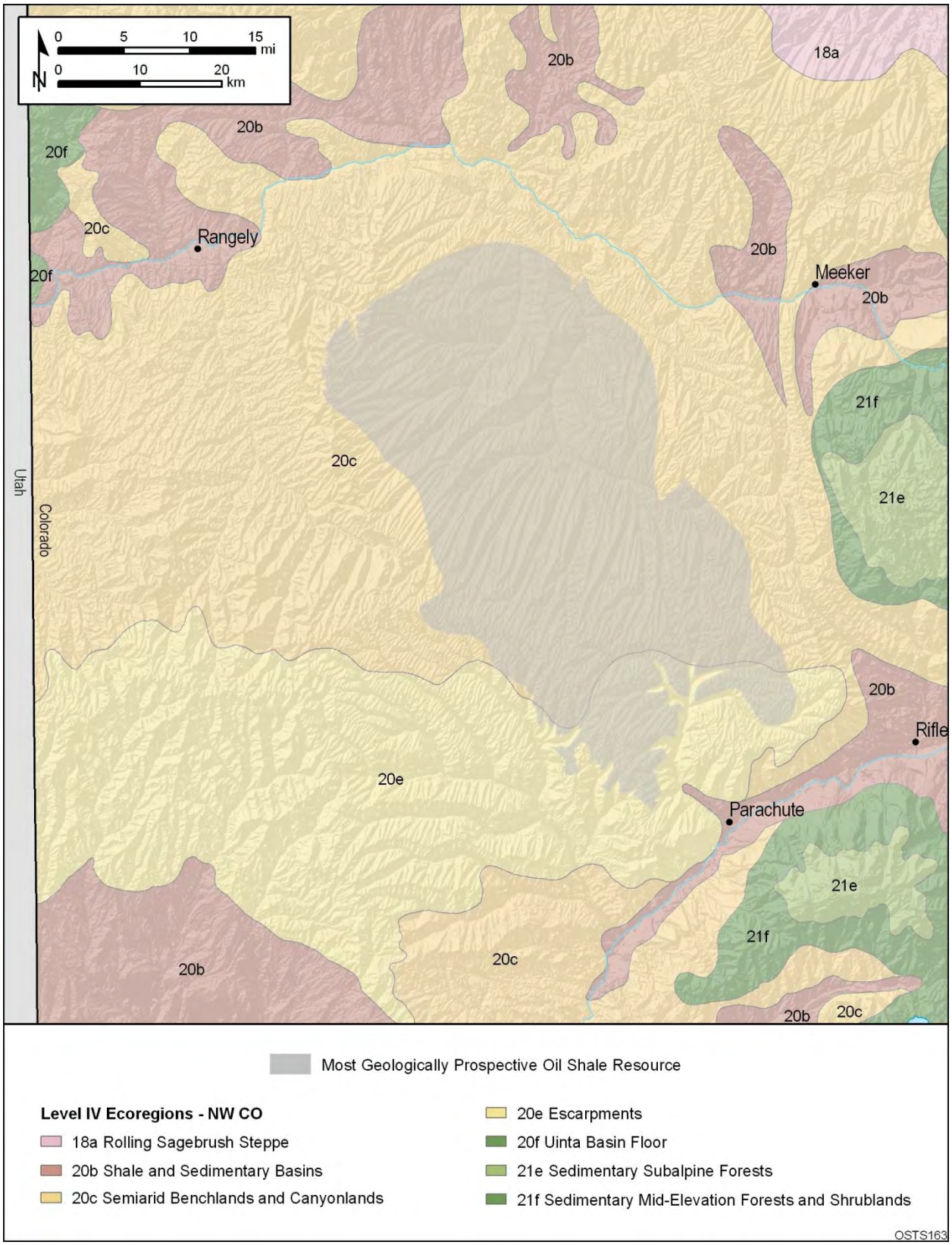

FIGURE 3.7.2-1 Ecoregions and Oil Shale Basin of Northwestern Colorado

[*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 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

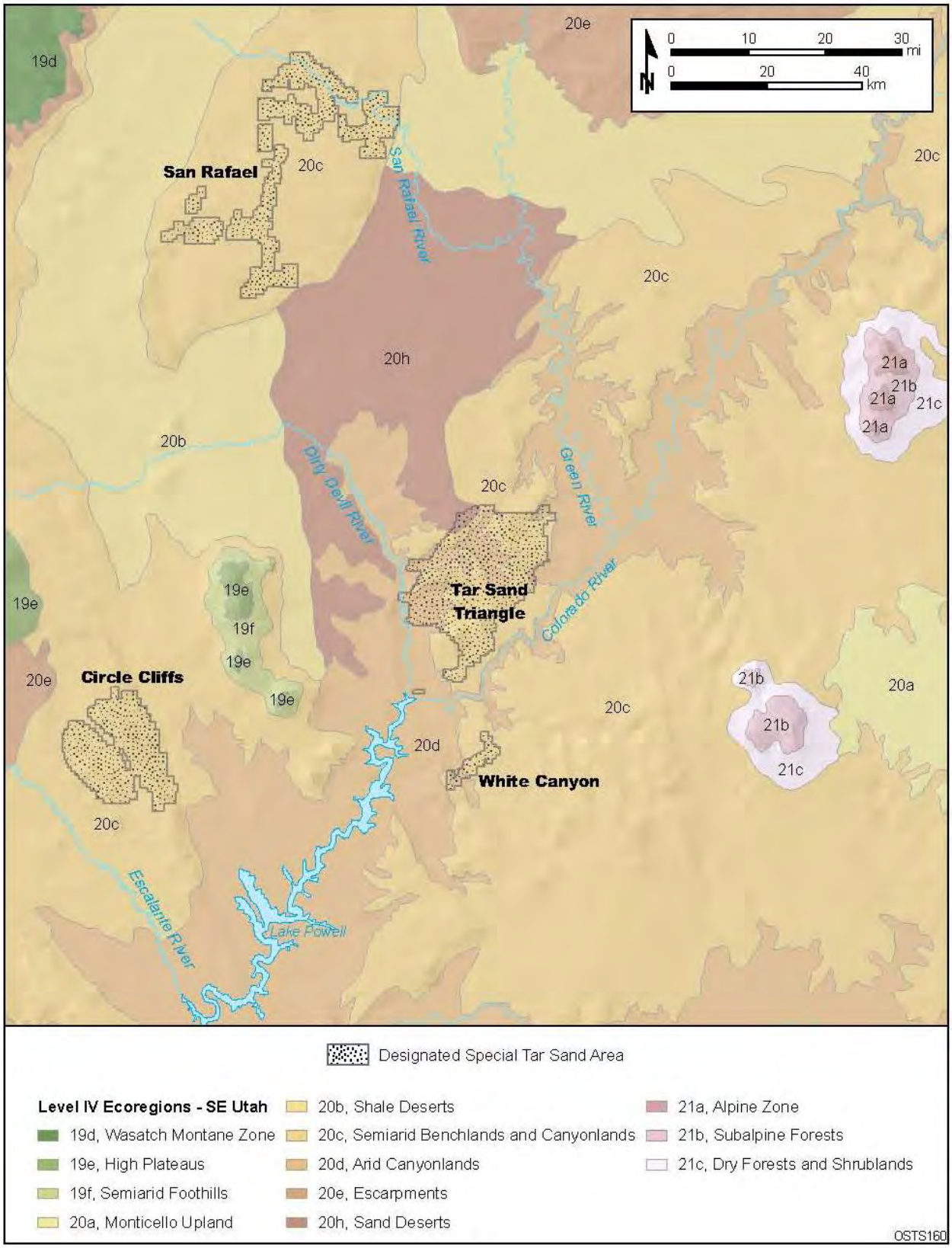

FIGURE 3.7.2-2 Ecoregions and Special Tar Sand Areas of Southeastern Utah

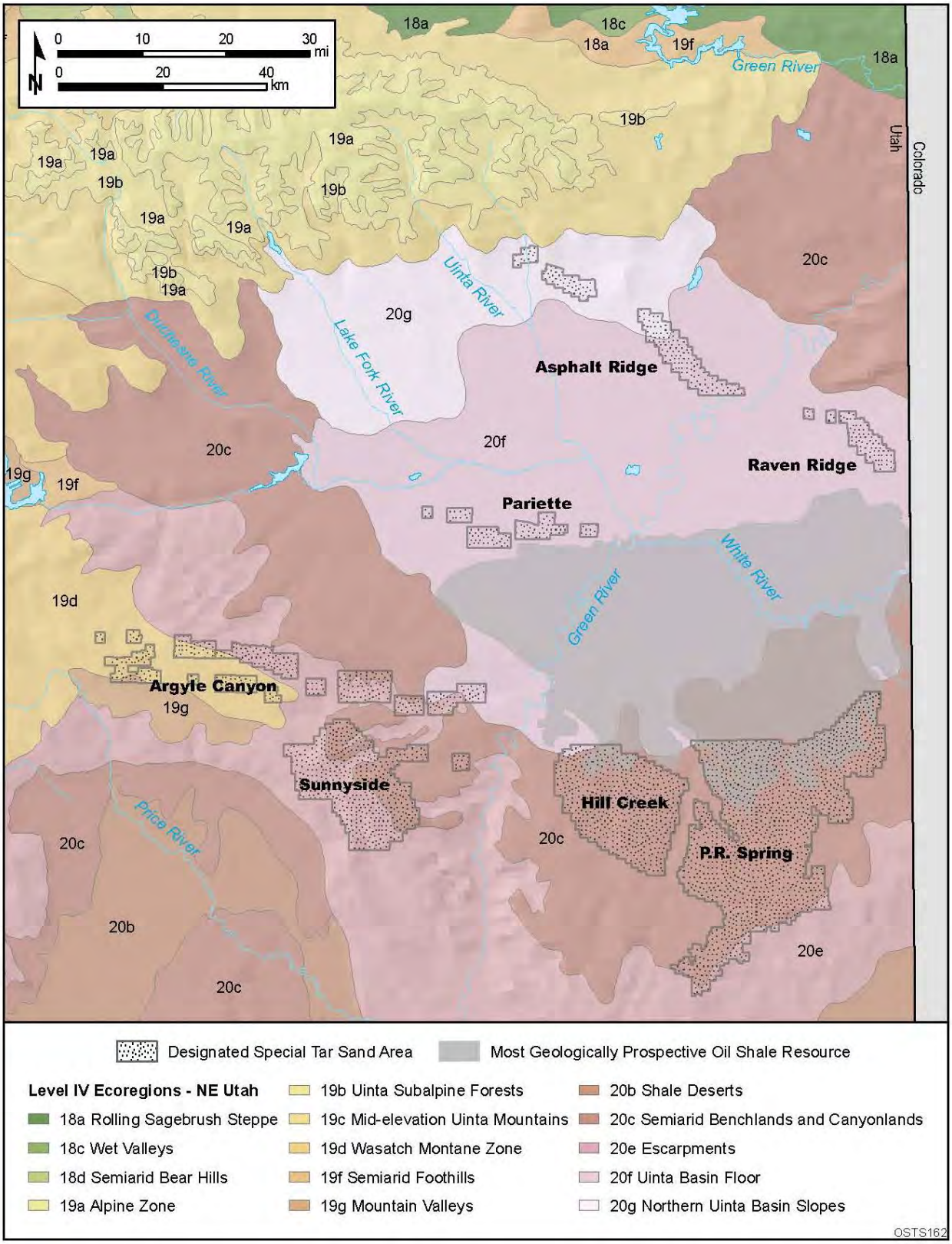

FIGURE 3.7.2-3 Ecoregions and Special Tar Sand Areas of Northeastern Utah

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.

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

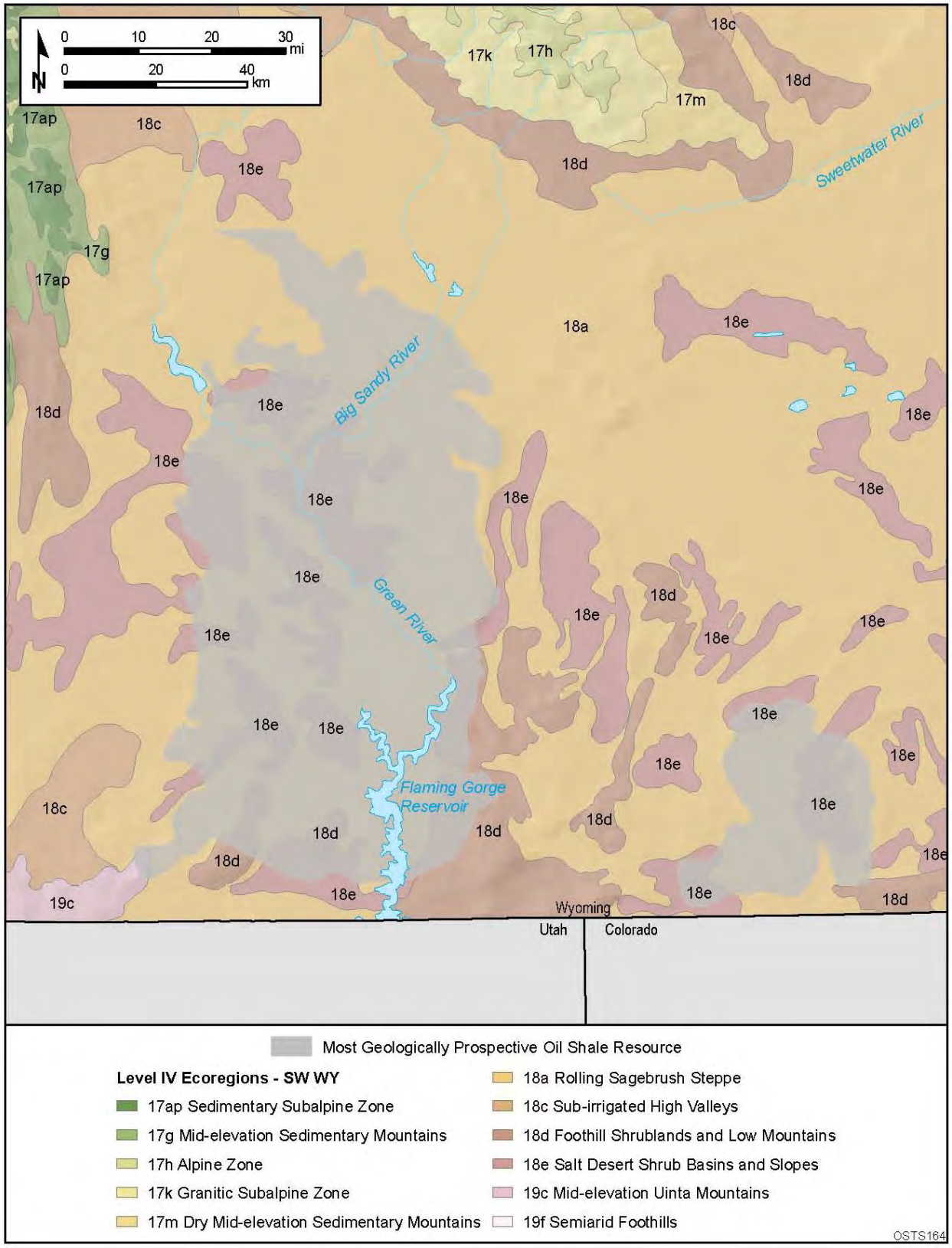

FIGURE 3.7.2-4 Ecoregions and Oil Shale Basins of Southwestern Wyoming

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 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

Table 1 WGFD 2009 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

Table 2 WGFD 2009 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

Table 3 WGFD 2009 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

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).

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 (including wild horses [*Equus caballus*] and wild burros [*E. asinus*]).[14] 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 BLM has active wildlife and wild horse management programs within each of its field offices. Wildlife management programs are largely aimed at habitat protection and

[14] Wild horses and burros are not considered to be, nor are they managed as, "wildlife" on BLM-administered lands. They are managed as a separate resource management category under the Wild Free-Roaming Horses and Burros Act. However, because wild horses and burros would be impacted by oil shale and tar sands development in a similar manner to that experienced by other large mammals, and since the consideration of site-specific impacts is not practicable within this PEIS, they are addressed under wildlife for ease of discussion.

improvement. The general objectives of wildlife management are to (1) maintain, improve, or enhance wildlife species diversity while ensuring healthy ecosystems, and (2) restore disturbed or altered habitat with the objective of obtaining desired native plant communities, while providing for wildlife needs and soil stability (BLM 1997b). The BLM is primarily responsible for managing habitats, while state agencies (i.e., Colorado Division of Wildlife [CDOW], 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 oversight of migratory bird species and of all federal threatened, endangered, or candidate species. BLM guidelines for the management of 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 Wild Free-Roaming Horses and Burros Act passed by Congress in 1971 gave the BLM the responsibility to protect, manage, and control wild horses and burros (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 following discussions present general descriptions of the wildlife species and of wild horses and burros 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.

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).

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 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.

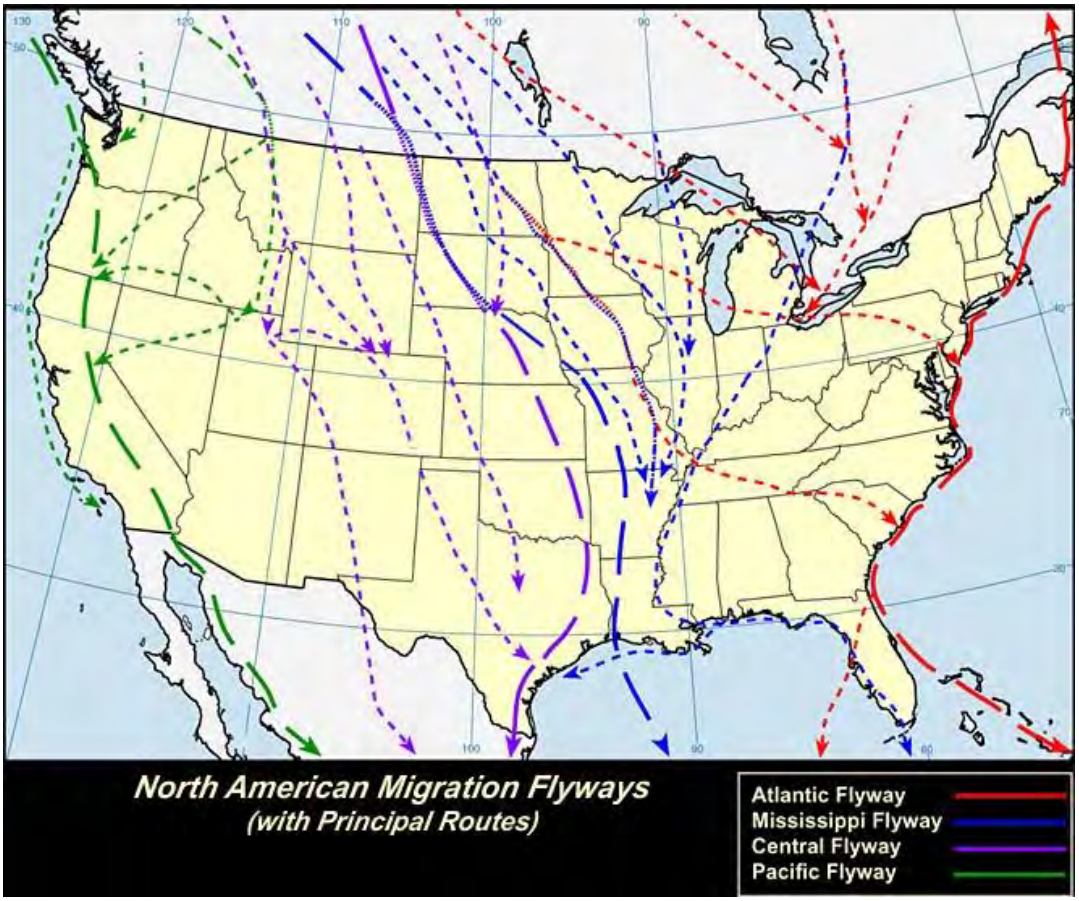

FIGURE 3.7.3-1 North American Migration Flyways (Coarse dashed lines are major flyways, medium dashed lines are principal migratory routes, fine dashed lines are merging routes; used with permission of birdnature.com, June 7, 2006.)

The 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).

The following discussion describes important groups 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), and/or (3) are representative of other species that share important habitats. 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)

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 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 Neotropical Migrants. Neotropical migrants are birds 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 neotropical migrants 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 neotropical migrants 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).

Neotropical migrant songbirds 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. Upland gamebirds 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 Endangered Species Act, 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). 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; Oraona 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). Wild horses, as well as 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. Wild horses and burros are discussed in Section 3.7.3.4, while threatened, endangered, and 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.

3.7.3.4 Wild Horses and Burros

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). 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 3.7.3-2 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 2006 are also provided. Figure 3.7.3-2 shows the distribution of the wild horse HMAs within the oil shale and tar sands study area.

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.

TABLE 3.7.3-2 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).

- 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*.

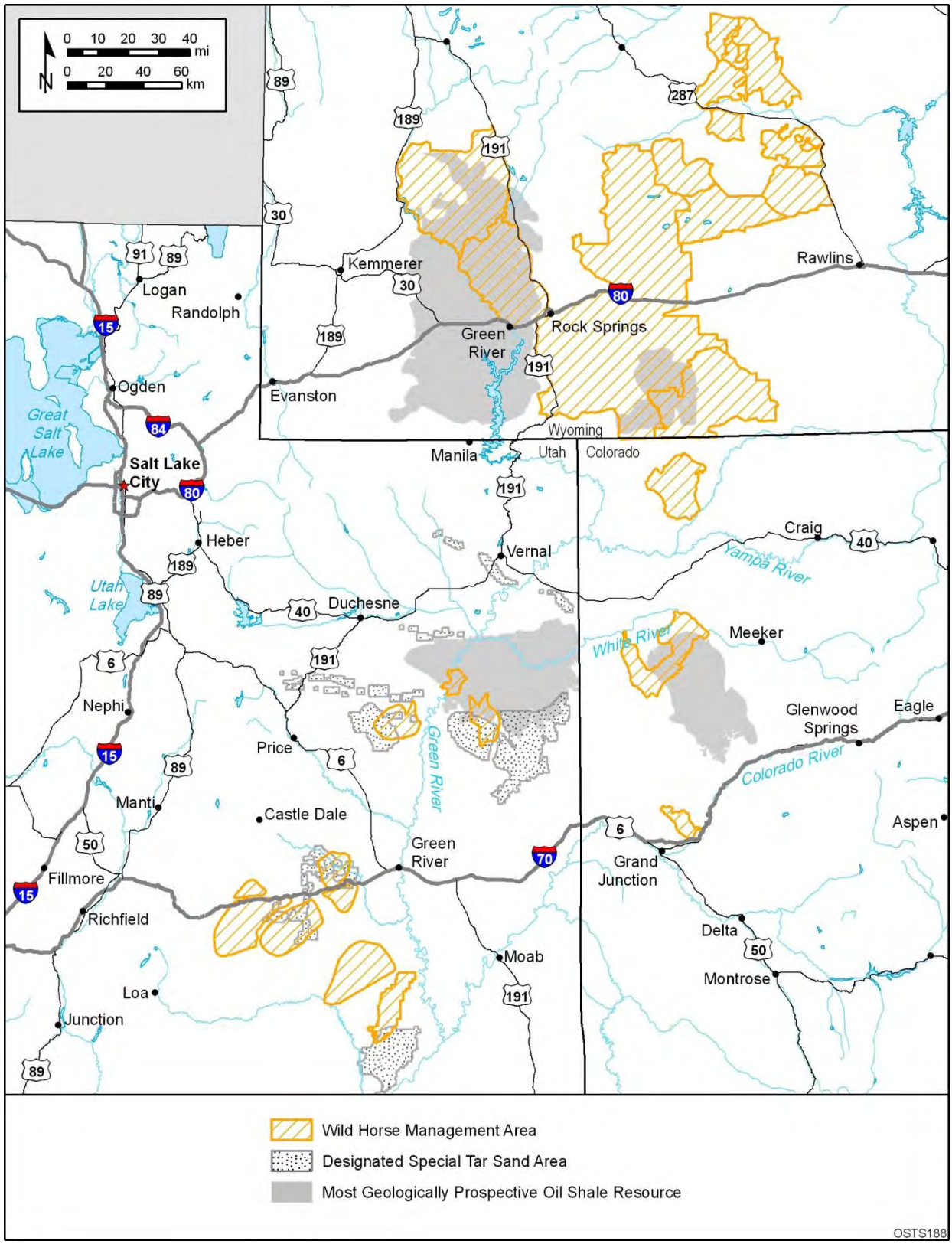

FIGURE 3.7.3-2 Distribution of Wild Horse Herd Management Areas within the Oil Shale and Tar Sands Study Area

- *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 227 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, 38 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 114 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.

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	13	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	38
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	0	23	15	126
Total species[a]	128	5	11	6	6	45	26	227

[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 Species Listed under the Endangered Species Act

There are 38 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 3.7.4-2 Federally and State-Listed Species That Occur within Counties with the Potential for Oil Shale or Tar Sands Development

	Oil Shale Basins and STSAs					
Status	Green River	Washakie	Piceance	Uinta	STSAs	Total[a]
USFWS						
Endangered	1	0	2	7	11	14
Threatened	1	0	6	6	10	16
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	38
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	130	90	0	0	0	126
Total species[b]	139	97	59	59	83	227

[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.

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 3.7.4-3 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

Species	Scientific Name	Listing Status[a]	Known or Potential Occurrence in Oil Shale Basins and STSAs[b]				
			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 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 glaucus*	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.

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. 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 National Wildlife Refuge (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 2011c).

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 2011c). 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 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).

3.7.4.1.11 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.

3.7.4.1.12 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.

3.7.4.1.13 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.

3.7.4.1.14 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.

3.7.4.1.15 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.

3.7.4.1.16 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.

3.7.4.1.17 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.

3.7.4.1.18 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.

3.7.4.1.19 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.

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.

3.7.4.1.20 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) (AGFD 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 (AGFD 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.

3.7.4.1.21 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.

3.7.4.1.22 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 2010a).

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 2010a), that identified recovery needs (surveying to accurately document populations and suitable habitat; protecting and restoring habitat and corridors to provide connectivity; and protecting individual plants from direct and indirect threats).

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 2010a).

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 2010a).

Some potential threats to the Pariette cactus include mineral and energy development, illegal collection, recreational off-road vehicle (ORV) 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 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.

3.7.4.1.23 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 National Wildlife Refuge. 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.

3.7.4.1.24 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.

3.7.4.1.25 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).

3.7.4.1.26 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.

3.7.4.1.27 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 USFWS found that the Pariette cactus warranted listing as endangered under the ESA, but that listing was precluded by other priorities. Each of the three species will continue to be considered threatened as part of the Uinta Basin hookless cactus complex until further action is taken. In the discussion below, all three species are referred to collectively as the Uinta Basin hookless cactus.

The Uinta Basin hookless cactus is a perennial species that occurs in Duchesne and Uintah Counties in Utah and in Delta, Garfield, Mesa, and Montrose Counties in Colorado (UDWR 2006). 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).

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 National Wildlife Refuge just north of the town of Ouray (USFWS 1990b). The species is also known to occur in Garfield County, Colorado (Colorado Rare Plant Technical Committee 1999). 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.

3.7.4.1.28 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).

3.7.4.1.29 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.

3.7.4.1.30 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 National Wildlife Refuge, Kansas; and Salt Plains National Wildlife Refuge, Oklahoma. The Aransas National Wildlife Refuge (ANWR), 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 National Wildlife Refuge 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 National Wildlife Refuge 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 National Wildlife Refuge. 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 (WBNP) 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 National Wildlife Refuge 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 WBNP 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 NWF 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.

3.7.4.1.31 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).

3.7.4.1.32 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 2011c). 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 2011c). 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.

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 D for additional information on Wyoming E.O. 2011-5. Similarly, the State of Utah maintains a database of priority habitat areas for the greater sage-grouse. These priority areas were determined by Utah DWR field biologists in 2010. BLM is currently working with the Utah DWR to refine the delineation of priority habitats in the State of Utah.

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 2011c). 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).

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.

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.[15]

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.

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

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[15] 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).

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.

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).

FIGURE 3.8.2-1 Landscape in the Piceance Basin

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 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.

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

FIGURE 3.8.2-2 Landscape in the Uinta Basin

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 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.

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

FIGURE 3.8.3-1 View from Wedge Overlook, San Rafael Swell near Castledale, Utah

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.

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

FIGURE 3.8.3-2 White Canyon Bridge on State Route 95, San Juan County, Utah

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 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

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.

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 1997 BLM National PA and State Protocols developed among the BLM, the National Council 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. 2007).

3.9.1 Section 106 of the NHPA 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 National Register of Historic Places (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. 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. 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) 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.

TABLE 3.9.1-1 Cultural Resource Exclusion Areas Intersecting Oil Shale or Tar Sands Areas

Exclusion Area	Field Office(s)	ACEC Acres 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				
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.

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.

- 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 (POD) 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 POD 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, who resided in the vicinity even after their official removal to reservations in the 1880s.

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. 2007) 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 found no new route, and the area was not visited again until the 1820s when the fur trade began to flourish in the region. 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 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 1,280 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 124,172 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 1,951. The number of sites that correspond to each site type is shown in

TABLE 3.9.2-1 Site Types of Known Archaeological Sites in the Piceance Basin, Colorado

Site Type	Number of Sites
Historic; architecture	100
Historic; isolated feature	7
Historic; isolated find	65
Historic; road or trail	20
Historic; all other site types	63
Total historic sites and isolated finds	255
Isolated feature	8
Isolated find	1,035
Open architecture	79
Open camp	269
Open lithic	284
Rock art	3
Shelter camp	9
Stone quarry	1
Total prehistoric sites and isolated features	1,688
No information	8

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.[16]

TABLE 3.9.2-2 Eligibility Status of Known Archaeological Sites in the Piceance Basin, Colorado

Eligibility Status	Number of Sites
Eligible	105
Not eligible	1,753
Eligibility undetermined	93
Total number of sites	1,951

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. 2007). High-sensitivity areas correspond to lower elevations in the central and northern portions of the Piceance Basin. Areas in the higher elevations in the southern third of the basin are considered areas of moderate site frequency, and areas that contained fewer sites than expected if site distribution were random correspond to the middle-elevation ridges and valleys.

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

[16] 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.

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. 2007) prepared in support of this PEIS.

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. 2007) 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 11,201 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 368,000 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 2,750 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 2,104. 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.[17]

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. 2007). High-sensitivity areas correspond to the valley of the White River and uplands in the northeastern third of the Uinta Basin. Areas in the higher elevations of the East Tavaputs Plateau south of the White River and west of Two Water Creek are considered areas of moderate sensitivity. Areas that contained fewer sites than expected if site distribution were random correspond to bottomland soils on the floodplains of the Green River and White River and high-elevation areas along the southwestern edge of the basin.

TABLE 3.9.3-1 Cultural Affiliations of Known Archaeological Sites in the Uinta Basin, Utah

Site Type	Number of Sites
Prehistoric	
Archaic	42
Fremont	6
Late Prehistoric	6
Paleoindian	3
Protohistoric	20
Unknown/other	283
No information available	4
Historic	
European/American	353
Ute/Paiute	21

TABLE 3.9.3-2 Eligibility Status of Known Archaeological Sites in the Uinta Basin, Utah

Eligibility Status	Number of Sites
Eligible	262
Not eligible	498
Eligibility undetermined	27
Data not available	1,317
Total number of sites	2,104

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

[17] 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.

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 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. 2007) 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. 2007) 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.[18]

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. 2007). High-sensitivity areas in the Green River Basin correspond to soils of the dissected plains and open or somewhat broken terrain where sand dunes are present. High-sensitivity areas in the Washakie Basin correspond to soils at low elevations. No moderate areas were identified in either the Green River Basin or Washakie Basin. Low site densities occur in the most highly elevated terrain in the Green River Basin and the elevated ridge and dissected plateau in the central portion of the Washakie Basin.

[18] 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

Site Type	Number of Sites: 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

Eligibility Status	Number of Sites: 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

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 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. 2007) 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 2,602 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 80,937 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 430 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 1,846 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 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.[19]

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. 2007). However, 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, San Rafael, Circle Cliffs, Asphalt Ridge, and Pariette STSAs. Sensitivity maps were generated for the remaining six STSAs on the basis of nonrandom associations between soil families and site frequency. In each of these STSAs, high-sensitivity areas are limited to one soil family each at White Canyon, Sunnyside, and Tar Sand Triangle STSAs, and two soil families each at Hill Creek, P.R. Spring, and Raven Ridge STSAs. The specific soil families are presented in O'Rourke et al. (2007).

3.10 INDIAN TRIBAL CONCERNS

As with other ethnic groups, Native Americans often express concern with preserving their traditional lifeways 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). 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 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,

[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.

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	0	11	14	1	2	0	0	7	10	0
Late Prehistoric	0	0	0	4	0	1	0	0	2	5	0
Fremont	0	0	5	17	0	0	0	3	53	2	0
Anasazi	0	0	1	0	0	0	0	0	0	3	0
Pueblo (general)	0	0	0	0	0	0	0	0	0	0	0
Numic	0	0	0	11	0	0	0	0	1	3	0
Ute/Paiute	0	0	0	0	2	0	0	0	1	0	0
Unknown Aboriginal	0	0	43	13	7	27	2	1	146	72	0
European/American	0	1	2	158	7	7	1	10	24	5	0
Historic Ute/Paiute	0	0	0	22	1	0	0	0	0	0	0
Unknown Historic	0	0	0	30	1	1	0	0	2	1	0
Multicomponent Prehistoric/Historic	0	0	9	16	1	1	0	2	9	1	0
No data	0	2	0	252	177	80	0	76	358	110	2
Total	0	3	71	540	197	120	3	92	603	215	2

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
Eligible	0	0	24	127	2	18	2	7	88	1	0	269
Not eligible	0	0	43	339	10	26	1	10	24	53	0	506
Eligibility undetermined	0	1	4	1	8	7	0	3	135	58	0	217
Data not available	0	2	0	73	177	69	0	72	356	103	2	854
Total number of sites	0	3	71	540	197	120	3	92	603	215	2	1,846

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 the Ute Indians. 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. The introduction of the horse allowed the Utes to venture more widely and to hunt buffalo on the plains.

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. Two tribes responded in conjunction with the 2008 PEIS. The Southern Utes responded that they know of no properties of religious or cultural significance that would be affected by the proposed development (Cloud 2006), while the Ute Indian Tribe of the Uintah and Ouray Reservation confined their comments to developments that would directly affect their reservation in the Uinta Basin (Natchees 2007).

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). To date, no specific properties have been identified (Bengston 2007).

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 responded to information regarding the 2008 PEIS. The tribe identified an area of tribal lands south of the Grand County–Uintah County border as pristine wilderness that included sacred hunting grounds. 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 possibly northeastern Utah. 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 1986). 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, 1986).

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 1986; 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).

During the preparation of the 2008 PEIS, the Eastern Shoshone, the Northern Arapaho, and the Northwestern Band of the Shoshone Nation each had some interaction with the BLM. Representatives of the BLM met with representatives of the Eastern Shoshone and Northern Arapaho to discuss oil shale and tar sands development in August of 2006. 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. 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, as discussed in Section 3.10.2. 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 farther west (Bengston 2007).

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).

3.11 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 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

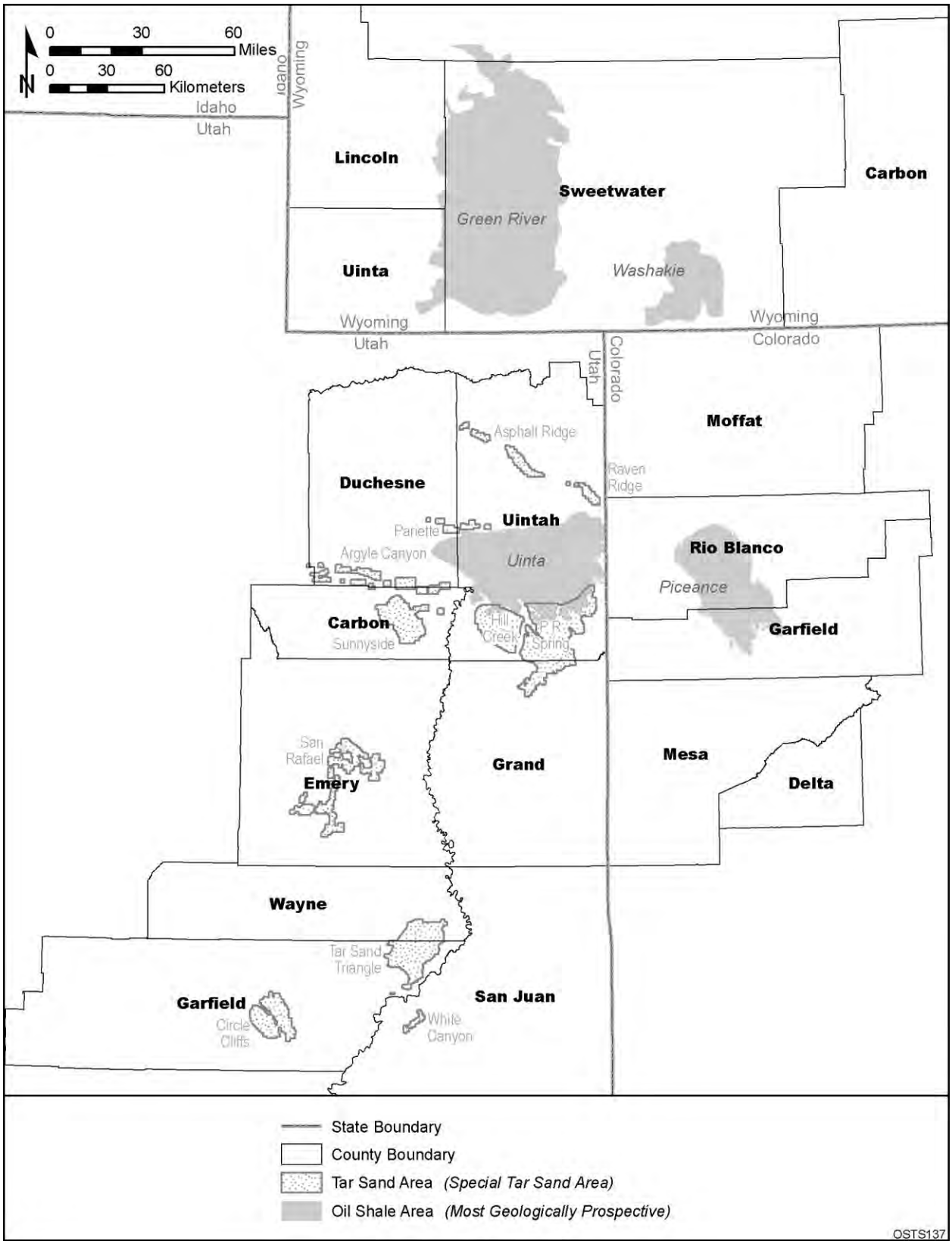

FIGURE 3.11.2-1 State ROIs for Oil Shale and Tar Sands Development Areas

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

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

TABLE 3.11.2-4 State and ROI Employment by Industry, 2009

Location	Agriculture[b]	Mining[a] Oil and Gas	Mining[a] Coal	Mining[a] Total	Construction	Manufacturing	Transportation and Utilities	Wholesale and Retail	Finance, Insurance, and Real Estate	Services	Other
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 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).

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 (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). 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

TABLE 3.11.2-5 State and ROI Personal Income

Location	$ billions 2010 2000	$ billions 2010 2009	Annual Average Growth, 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).

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 Walmart 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.

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.

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).

TABLE 3.11.2-7 ROI Urban Population and Income for the Colorado 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]
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).

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 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.

TABLE 3.11.2-8 ROI Urban Population and Income for the Utah ROI

	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]
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.)

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]
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).

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

TABLE 3.11.2-9 ROI Urban Population and Income for the Wyoming 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]
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%
Kemmerrer	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.)

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]
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).

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 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%.

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

TABLE 3.11.2-10 ROI Housing Characteristics

Parameter	Number of Units 2000	Number of Units 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).

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.

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).

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)

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).

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

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).

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).

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.

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

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).

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 (5.4%) are slightly higher than the national average (4.1%) and the rate for Utah (4.1%). Data for

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).

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

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).

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.

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 2000 Census (U.S. Census Bureau 2007). 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 2000 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 1999, for example, the poverty line for a family of five with three children below the age of 18 was $19,882. 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 2007).

  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 2000 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 2000 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 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

TABLE 3.12-1 Minority and Low-Income Populations in the Oil Shale Resource Area and Buffer

Population Segment	Colorado Block Groups	Utah Block Groups	Wyoming Block Groups
Total population	207,319	72,795	77,966
White, non-Hispanic	176,798	64,089	69,054
Hispanic or Latino	24,768	4,051	5,195
Non-Hispanic or Latino minorities	5,753	4,655	3,717
One race	3,284	3,646	2,736
Black or African American	761	131	369
American Indian or Alaskan Native	1,245	3,248	1,929
Asian	968	182	356
Native Hawaiian or other Pacific Islander	144	42	36
Some other race	166	43	46
Two or more races	2,469	1,009	981
Total minority	30.521	8,706	8,912
Low-income	18,765	9,713	6,953
Minority			
ROI	14.7%	12.0%	11.4%
State	34.0%	19.8%	14.3%
Low-income			
ROI	9.1%	13.3%	8.9%
State	9.0%	9.2%	11.1%

Source: U.S. Census Bureau (2007).

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 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.

TABLE 3.12-2 Minority and Low-Income Populations in the Tar Sands Resource Area and Buffer

Population Segment	Arizona Block Groups	Colorado Block Groups	Utah Block Groups	Wyoming Block Groups
Total population	3,051	117,465	388,585	6,721
White, non-Hispanic	58	102,109	337,000	6,252
Hispanic or Latino	18	11,823	27,012	315
Non-Hispanic or Latino minorities	3,033	3,533	24,573	154
One race	3,009	2,001	19,487	88
Black or African American	5	455	966	11
American Indian or Alaskan Native	2,945	734	13,195	55
Asian	0	596	3,328	14
Native Hawaiian or other Pacific Islander	1	105	1,648	1
Some other race	0	111	350	7
Two or more races	24	1,532	5,086	66
Total minority	2,993	15,356	51,585	469
Low-income	1,430	11,611	57,014	531
Minority				
ROI	98.1%	13.1%	13.3%	7.0%
State	36.2%	34.0%	19.8%	14.3%
Low-income				
ROI	46.9%	9.9%	14.7%	7.9%
State	13.9%	9.0%	9.2%	11.1%

Source: U.S. Census Bureau (2007).

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

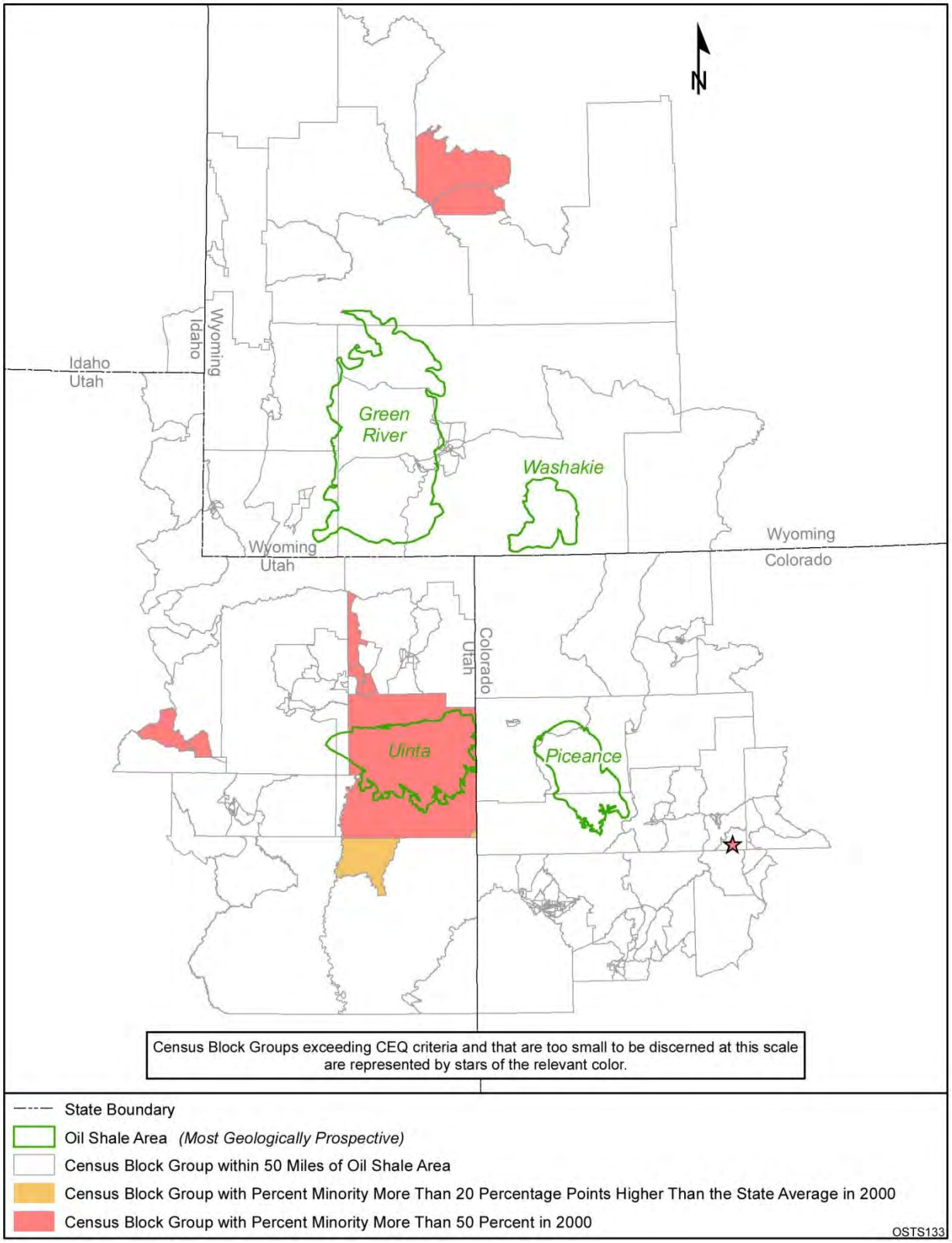

FIGURE 3.12-1 Minority Population Concentration in Census Block Groups within Oil Shale Resource Areas and Associated 80-km (50-mi) Buffer

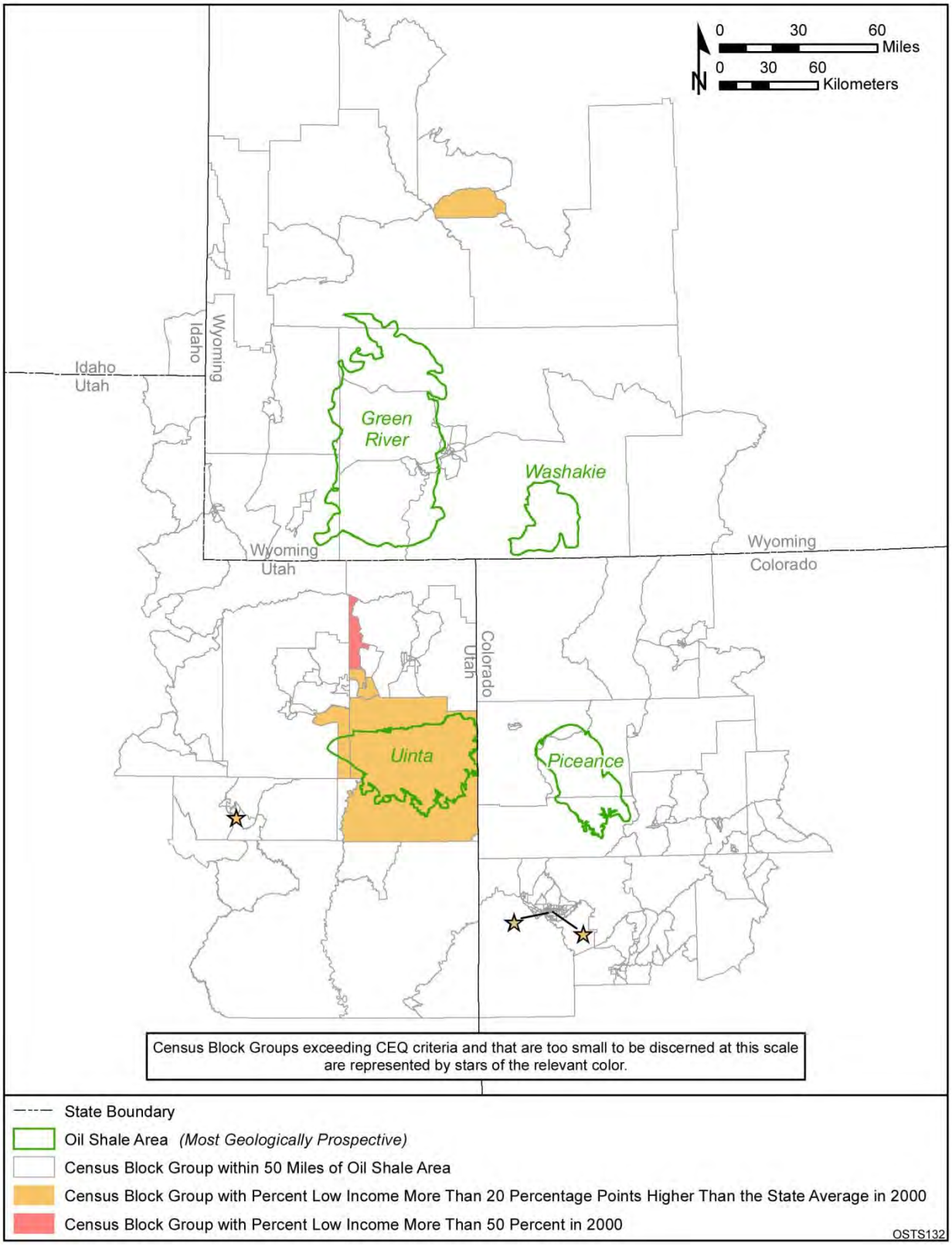

FIGURE 3.12-2 Low-Income Population Concentration in Census Block Groups within Oil Shale Resource Areas and Associated 80-km (50-mi) Buffer

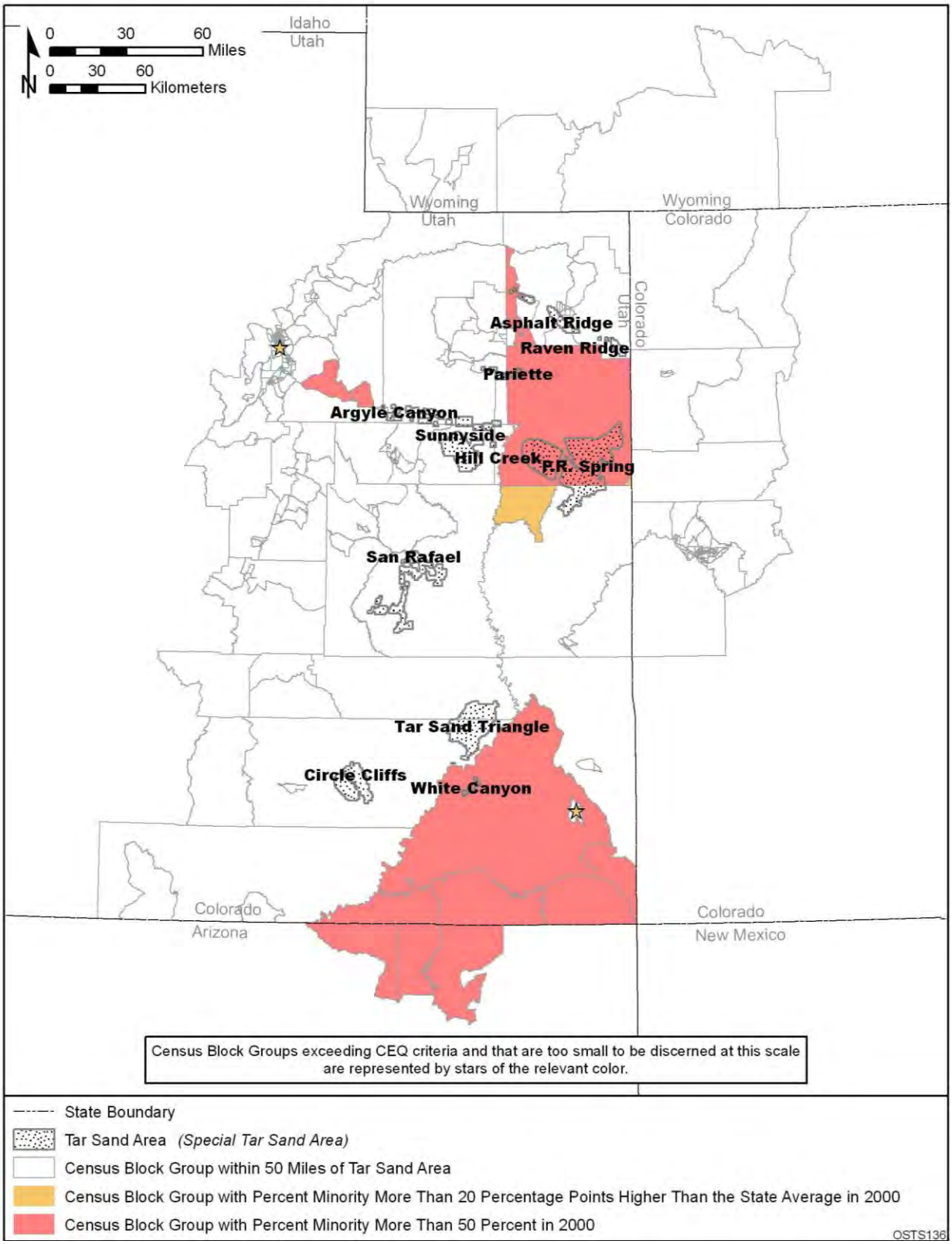

FIGURE 3.12-3 Minority Population Concentration in Census Block Groups within Tar Sands Resource Areas and Associated 80-km (50 mi) Buffer

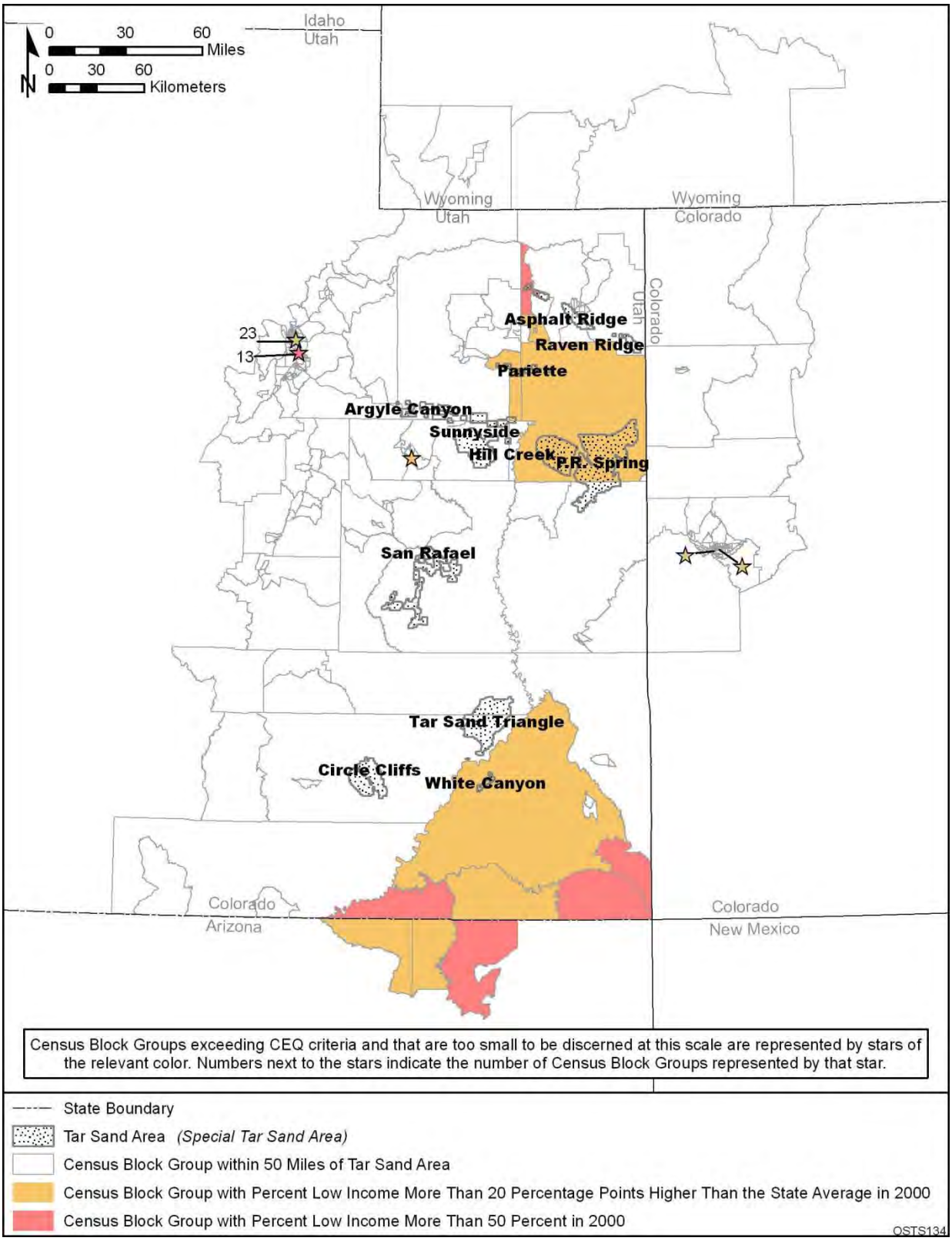

FIGURE 3.12-4 Low-Income Population Concentration in Census Block Groups within Tar Sands Resource Areas and Associated 80-km (50 mi) Buffer

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.

Acoustical Society of America, 1983, *American National Standard Specification for Sound Level Meters*, ANSI S1.4-1983, New York, N.Y.

Acoustical Society of America, 1985, *American National Standard Specification for Sound Level Meters, ANSI S1.4A-1985 Amendment to ANSI S1.4-1983*, New York, N.Y., June 26.

Adams, D.B., et al., 1986, *Hydrologic Data from Roan Creek and Parachute Creek Basins, Northwestern Colorado*, U.S. Geological Survey Open-File Report 83-859.

AGFD (Arizona Game and Fish Department), 2006, *Arizona Game and Fish Department Heritage Data Management System: Plant Abstracts, Distribution, Maps and Illustrations.* Available at http://www.azgfd.gov/w_c/edits/hdms_abstracts_plants.shtml. Accessed July 19, 2006.

AMA (American Medical Association), 2011, *Physician-Related Data Resources*. Available at http://www.ama-assn.org/ama/pub/category/2676.html.

Andrews, E.D., 1983, "Denudation of the Piceance Creek Basin, Colorado," pp. 205–215, in *Dissolved Loads of Rivers and Surface Water Quantity/Quality Relationships*, IAHS Pub. No. 141, Proceedings of the Hamburg Symposium, August.

Archer, S.R., and K.I. Predick, 2008, "Climate Change and Ecosystems of the Southwestern United States," *Rangelands* 30:23–28.

Atwood, D., et al., 1991, *Utah Endangered, Threatened and Sensitive Plant Field Guide*, Utah Threatened and Endangered Species Act Plant Interagency Committee.

Austin, J., and A. Richert, 2001, *A Comprehensive Review of Observational and Site Evaluation Data of Migrant Whooping Cranes in the United States, 1943–99*, U.S. Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, N.D. Available at http://www.npwrc.usgs.gov/resource/birds/wcdata/pdf/wcdata.pdf. Accessed Sept. 21, 2010.

Barrick, K., 1986, *Option Value in Relation to Distance Effects and Selected User Characteristics for the Washakie Wilderness, Northeast Wyoming*, National Wilderness Research Conference, U.S. Forest Service, Intermountain Research Station, Ogden, Utah.

Bauch, N.J., and N.E. Spahr, 1998, "Salinity Trends in Surface Waters of the Upper Colorado River Basin, Colorado," *Journal of Environmental Quality* 27:640–655.

BBC Research and Consulting, 2004, *The Economic Impacts of Hunting, Fishing, and Wildlife Watching in Colorado*, prepared for Colorado Division of Wildlife, Oct. 31.

Behnke, R.J., 1992, *Native Trout of Western North America*, Monograph 6, American Fisheries Society, Bethesda, Md.

Behnke, R.J., et al., 1982, "A Survey and Analysis of Existing Information on Fishes in Northwest Colorado," Vol. 6 of *Wildlife Conservation and Energy Development in Northwest Colorado*, D.W. Crumpacker (editor), Ecological Services Section, Colorado Division of Wildlife, Denver, Colo.

Behrens, J., and J. Brooks, 2000, "Wind in Their Wings: The Condor Recovery Program," *Endangered Species Bulletin* XXV:8–9, May/June.

Beidleman, C.A., 2000, *Colorado Land Bird Conservation Plan Version 1.0*, Colorado Partners in Flight. Available at http://www.blm.gov/wildlife/plan/pl-co-10.pdf. Accessed Sept. 26, 2006.

Belica, L.T., and N.P. Nibbelink, 2006, *Mountain Sucker* (Catostomus platyrhynchus)*: A Technical Conservation Assessment*, USDA Forest Service, Rocky Mountain Region, Golden, Colo., Aug. Available at http://www.fs.fed.us/r2/projects/scp/assessments/mountainsucker.pdf. Accessed May 13, 2008.

Belnap, J., and D.H. Campbell, 2011, *Effects of Climate Change and Land Use on Water Resources in the Upper Colorado River Basin*, U.S. Geological Survey Fact Sheet 2010–3123.

Bengston, G., 2007, unpublished information, Argonne National Laboratory, Argonne, Ill.

Berry, E.H., et al., 1990, "A Longitudinal Analysis of Neighboring in Rapidly Changing Rural Places," *Journal of Rural Studies* 6:175–186.

Bestgen, K.R., and M.A. Williams, 1994, "Effects of Fluctuating and Constant Temperatures on Early Development and Survival of Colorado Squawfish," *Transactions of the American Fisheries Society* 123:574–579.

Bestgen, K.R., et al., 1998, *Downstream Transport of Colorado Squawfish Larvae in the Green River Drainage: Temporal and Spatial Variation in Abundance and Relationships with Juvenile Recruitment,* Larval Fish Laboratory, Colorado State University, Fort Collins, Colo.

Bestgen, K.R., et al., 2002, *Status of Wild Razorback Sucker in the Green River Basin, Utah and Colorado, Determined from Basinwide Monitoring and Other Sampling Programs*, Larval Fish Laboratory, Colorado State University, Fort Collins, Colo.

Bezzerides, N., and K. Bestgen, 2002, *Status Review of Roundtail Chub,* Gila Robusta*, Flannelmouth Sucker,* Catostomus Latipinnis*, and Bluehead Sucker,* Catostomus discobolus*, in the Colorado River Basin*, Larval Fish Lab Contribution 118, Colorado State University, Fort Collins, Colo.

Birdnature.com, 2001, *North American Migration Flyways*. Available at http://www.bird nature.com/flyways.html. Accessed Sept. 26, 2006.

Blackett, R.E., 1996, *Tar-Sand Resources of the Uinta Basin, Utah: A Catalog of Deposits,* Open-File Report 335, Utah Geological Survey.

BLM (Bureau of Land Management), 1980, *Green River–Hams Fork Draft Environmental Impact Statement: Coal,* Denver, Colo.

BLM, 1981, *Planning for Recreation Resources*, BLM Handbook 8320, U.S. Department of the Interior.

BLM, 1983a, *Final Supplemental Environmental Impact Statement for the Prototype Oil Shale Leasing Program,* Colorado State Office, Denver, Colo., Jan.

BLM, 1983b, *Final Environmental Impact Statement on the Glenwood Springs Resource Management Plan*, Glenwood Springs, Colo., June.

BLM, 1983c, *Final Environmental Impact Statement, Uintah Basin Synfuels Development*, Vol. 1, U.S. Department of the Interior, Feb.

BLM, 1984a, *Visual Resource Management Handbook*, BLM Handbook 8400, Release 8-24, U.S. Department of the Interior, April.

BLM, 1984b, *Utah Combined Hydrocarbon Leasing Regional Final EIS, Volume 1: Regional Analyses*, Utah State Office, Salt Lake City, Utah, June.

BLM, 1985a, *Record of Decision and Rangeland Program Summary for the Book Cliffs Resource Management Plan*, Vernal District Office, Utah, May.

BLM, 1985b, *Piceance Basin Resource Management Plan*, White River Field Office, Colo.

BLM, 1985c, *Grand Junction Resource Area Management Plan and Environmental Impact Statement*, Draft, Grand Junction District, Colo., March.

BLM, 1986a, *Visual Resource Inventory*, BLM Manual Handbook 8410-1, Release 8-28, U.S. Department of the Interior, Jan. 17.

BLM, 1986b, *Visual Resource Contrast Rating*, BLM Manual Handbook 8431-1, Release 8-30, U.S. Department of the Interior, Jan. 17.

BLM, 1987a, *Grand Junction Resource Area Resource Management Plan and Record of Decision*, Grand Junction District, Colo., Jan.

BLM, 1987b, *San Juan Resource Management Plan Proposed Resource Management Plan, Final Environmental Impact Statement*, Vol. 1, San Juan Resource Area, Moab District, Utah, Sept.

BLM, 1987c, *Salinity Control on BLM-administered Public Lands in the Colorado River Basin: A Report to Congress,* BLM Service Center, Denver, Colo.

BLM, 1988, *Record of Decision and Resource Management Plan,* Glenwood Springs Resource Area, Grand Junction District, Colo., June.

BLM, 1991a, *San Rafael Final Resource Management Plan*, Moab District, San Rafael Resource Area, Utah, May.

BLM, 1991b, *Resource Management Plan Record of Decision and Rangeland Program Summary for the San Juan Resource Area, Moab District, Utah*, Utah, March.

BLM, 1994a, *Diamond Mountain Resource Area Resource Management Plan and Record of Decision*, Vernal District Office, Utah.

BLM, 1994b, *White River Resource Area Draft Resource Management Plan and Environmental Impact Statement*, Craig District, Colo., Oct.

BLM, 1996, *White River Resource Area Proposed Resource Management Plan and Final Environmental Impact Statement*, Colorado State Office, White River Resource Area, Craig District, Colo., June.

BLM, 1997a, *White River Record of Decision and Approved Resource Management Plan*, White River Resource Area, Craig District, Meeker, Colo., July.

BLM, 1997b, *Record of Decision and Green River Resource Management Plan*, Green River Resource Area, Rock Springs District Office, Wyo., Oct.

BLM, 1999a, *Grand Staircase–Escalante National Monument Approved Management Plan Record of Decision,* Grand Staircase–Escalante National Monument, Cedar City, Utah, Nov.

BLM, 1999b, *Glenwood Springs Resource Area Oil & Gas Leasing & Development Record of Decision and Resource Management Plan Amendment*, Colorado State Office, March.

BLM, 2001a, *Environmental Assessment Record, Oil Shale Withdrawal Revocation/RMP Amendments*, Grand Junction Field Office, White River Field Office, and Glenwood Springs Field Office, Nov.

BLM, 2001b, *Recreation Guide to the San Rafael Area*, Price Field Office, Price, Utah. Available at http://www.blm.gov/utah/price/SanRafaelDesert.htm. Accessed June 1, 2006.

BLM, 2002a, *Mineral Potential Report for Price Field Office, Carbon and Emery Counties, Utah*, Price Field Office, Utah, Aug.

BLM, 2002b, *Mineral Potential Report for the Vernal Planning Area*, Vernal Field Office, Utah, Oct.

BLM, 2002c, *Decision Record, Finding of No Significant Impact and Environmental Assessment for 2-D Seismic Exploration by Veritas DGC Land, Inc., Uintah County, Utah*, EA No. UT-080-2002-21, Vernal Field Office, Utah, Oct.

BLM, 2002d, personal communication from K. Bartel (Bureau of Land Management, Vernal Field Office, Vernal, Utah) to D. Harris (SWCA Environmental Consultants, Vernal, Utah), April 2.

BLM, 2003, *Kemmerer Field Office Planning Area: Summary of the Management Situation Analysis*, Kemmerer, Wyo., Nov.

BLM, 2004a, *Kemmerer Field Office Planning Area Mineral Assessment Report*, Kemmerer Field Office, Wyo., Jan.

BLM, 2004b, *Final Environmental Impact Statement for the Jack Morrow Hills Coordinated Activity Plan, Proposed Green River Resource Management Plan Amendment*, Rock Springs Field Office, Wyo., July.

BLM, 2004c, *Draft Roan Plateau Resource Management Plan Amendment and Environmental Impact Statement*, Colorado State Office, Glenwood Springs Field Office, Colo., Nov.

BLM, 2004d, *Final Environmental Impact Statement for the Jack Morrow Hills Coordinated Activity Plan, Proposed Green River Resource Management Plan Amendment*, Rock Springs Field Office, Wyo., July.

BLM, 2004e, *Rawlins Resource Management Plan and Draft Environmental Impact Statement*, Rawlins Field Office, Wyo., Dec.

BLM, 2004f, *Environmental Assessment for the West Tavaputs Plateau Drilling Program, Carbon and Duchesne Counties, Utah*, UT-070-2004-28, Price Field Office, Price, Utah, July.

BLM, 2005a, *Mineral Potential Report*, Richfield Field Office, Utah, March.

BLM, 2005b, *Reasonably Foreseeable Development Scenario for Oil and Gas*, Richfield Field Office, Utah, March.

BLM, 2005c, *Wild and Scenic River Eligibility and Tentative Classification Report*, Richfield Field Office, Utah, March.

BLM, 2005d, *Evaluation Report, Areas of Critical Environmental Concern, Richfield Resource Management Plan*, Richfield Field Office, Utah, Jan.

BLM, 2005e, *Draft Resource Management Plan Revision and Environmental Impact Statement for the Vernal Field Office Planning Area*, Vernal Field Office, Utah, Jan.

BLM, 2005f, *West Douglas Herd Area Amendment to the White River Resource Management Plan, Environmental Assessment (CO-WRFO-05-083-EA)*, White River Field Office, Colo., April.

BLM, 2006a, *Roan Plateau Planning Area, Including Former Naval Oil Shale Reserves Numbers 1 and 3, Resource Management Plan Amendment and Environmental Impact Statement*, Colorado State Office, Aug.

BLM, 2006b, *Record of Decision and Jack Morrow Hills Coordinated Activity Plan/Green River Resource Management Plan Amendment*, Rock Springs Field Office, Wyo., July.

BLM, 2006c, *Monticello Field Office Mineral Potential Report*, Monticello Field Office, Utah. Available at http://www.blm.gov/rmp/ut/monticello/MFO_MPR.htm. Accessed July 7, 2006.

BLM, 2006d, *Environmental Assessment: 9 APDs for Wells Piceance Creek Unit (PCU): PCU T75X-3G1, -3G2, -3G3, -3G4, -3G5, -3G6, -3G7, -3G8, & -3G9*, CO-110-2006-009-EA, White River Field Office, Meeker, Colo.

BLM, 2006e, *Resource Development Group Uinta Basin Natural Gas Project: Final Environmental Impact Statement*, UT-080-2003-0300V, Vernal Field Office, Vernal, Utah, May.

BLM, 2006f, *San Rafael Swell Study*. Available at http://www.ut.blm.gov/sanrafaelswell/objectsofinterest/ecology.htm. Accessed July 18, 2006.

BLM, 2006g, *Environmental Assessment, Shell Oil Shale Research, Development and Demonstration Projects, Rio Blanco County, Colorado*, CO-110-2006-117-EA, White River Field Office, Meeker, Colo., Nov.

BLM, 2006h, *Environmental Assessment, Chevron Oil Shale Research, Development & Demonstration*, CO-110-2006-120-EA, White River Field Office, Meeker, Colo., Nov.

BLM, 2006i, personal communication from D. Hanson (BLM Wyoming State Office) to T. Patton (Argonne National Laboratory, Argonne, Ill.), June 20.

BLM, 2007a, *Record of Decision for the Approval of Portions of the Roan Plateau Management Plan Amendment and Environmental Impact Statement*, Glenwood Springs Field Office, Colo., June.

BLM, 2007b, *Price Field Office Supplemental Draft Resource Management Plan and Environmental Impact Statement for Non-Wilderness Study Area (WSA) Lands with Wilderness Characteristics,* Price Field Office, Utah, Sept.

BLM, 2007c, *Potential Fossil Yield Classification (PFYC) System for Paleontological Resources on Public Lands*, Instruction Memorandum No. 2008-009, with attachments, Washington, D.C., Oct. 15.

BLM, 2007d, personal communication from C. Hollowed (Bureau of Land Management, White River Field Office, Meeker, Colo.) to J. May (Argonne National Laboratory, Lakewood, Colo.), Feb. 14.

BLM, 2008a, *Record of Decision for the Resource Management Plan Amendment for Portions of the Roan Plateau Planning Area Designated as Areas of Critical Environmental Concern Public Lands in Garfield County, CO*, March.

BLM, 2008b, *Assessment and Mitigation of Potential Impacts to Paleontological Resources*, Instruction Memorandum No. 2009-011, with attachments, Washington, D.C., Oct. 10.

BLM, 2008c, *Proposed Resource Management Plan and Final Environmental Impact Statement for Public Lands Administered by the BLM Rawlins Field Office*, Rawlins, Wyo., January.

BLM, 2008d, *Proposed Resource Management Plan Revision and Final Environmental Impact Statement for the Vernal Field Office Planning Area*, Vernal Field Office, Utah, Aug.

BLM, 2008e, *Proposed Resource Management Plan and Final Environmental Impact Statement for the Price Field Office*, Price Field Office, Utah, Aug.

BLM, 2008f, *Record of Decision, Monticello Field Office Resource Management Plan*, Monticello Field Office, Utah, Nov.

BLM, 2008g, *Record of Decision, Price Field Office Resource Management Plan,* Price, Utah, Oct.

BLM, 2008h, *Special Status Species Management*, BLM Manual 6840, Dec. 12.

BLM, 2008i, *Richfield Field Office Record of Decision and Approved Resource Management Plan*, BLM-UT-PL-09-002-1610 UT-050-2007-090 EIS, Richfield Field Office, Richfield, Utah, Oct. Available at http://www.blm.gov/pgdata/etc/medialib/blm/ut/richfield_fo/planning/rmp/rod_approved_rmp.Par.29760.File.dat/Richfield%20Final%20Plan.pdf. Accessed Nov. 8, 2011.

BLM, 2009, *A New Paleontology Law: Paleontological Resources Preservation under the Omnibus Public Lands Act of 2009,* brochure, U.S. Department of the Interior, Washington, D.C. Available at http://www.blm.gov/pgdata/etc/medialib/blm/ut/natural_resources/cultural/paleo/paleontology_opla-prp.Par.22491.File.dat/PRP%20print.pdf. Accessed Aug. 30, 2011.

BLM, 2010a, *Record of Decision, Kemmerer Resource Management Plan*, Kemmerer Field Office, Wyo., May.

BLM, 2010b, *Sage-Grouse and Sagebrush Conservation*. Available at http://www.blm.gov/wo/st/en/prog/more/sage_grouse_home2.html. Accessed Sept. 28, 2011.

BLM, 2011a, *Herd Area (HA) and Herd Management Area (HMA) Data for Fiscal Years 2005-2011*, Wild Horse and Burro Program, Washington, D.C. Available at http://www.blm.gov/wo/st/en/prog/wild_horse_and_burro/wh_b_information_center/statistics_and_maps/ha_and_hma_data.html. Accessed Sept. 28, 2011.

BLM, 2011b, *Idaho's Wildlife: Sensitive Species, Greater Sage-Grouse*. Available at http://www.blm.gov/id/st/en/prog/wildlife/sensitive_species/greater_sage-grouse.html. Accessed Sept. 28, 2011.

BLM, 2011c, personal communication from L. Belmonte (Bureau of Land Management, White River Field Office, Meeker, Colo.) to M. Grippo (Argonne National Laboratory), Dec. 1.

BOR (U.S. Bureau of Reclamation), 1988, *Hydrologic Determination on Water Availability from Navajo Reservoir and the Upper Colorado River Basin for Use in New Mexico*, U.S. Department of the Interior, Feb. 2.

BOR, 1995, *Operation of Glen Canyon Dam: Colorado River Storage Project: Final Environmental Statement*, March. Available at http://www.usbr.gov/uc/library/envdocs/eis/gc/pdfs/Cov-con/cov-con.pdf. Accessed Oct. 6, 2011.

BOR, 2004, *Colorado River System Consumptive Uses and Losses Report 1996–2000*, U.S. Department of the Interior, Bureau of Reclamation, Feb.

BOR, 2005, *Operation of Flaming Gorge Dam Final Environmental Impact Statement*, U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah, Sept.

BOR, 2006, *Duchesne River Solar-Powered Automation Network*. Available at http://www.usbr.gov/uc/provo/progact/ca/proj_duchesne.html. Accessed May 5, 2006.

Boulding, E., 1981, "Women as Integrators and Stabilizers," pp. 119–149, in *Women and the Social Cost of Energy Development: Two Colorado Case Studies,* E. Moen et al. (editors), Westview Press, Boulder, Colo.

Boulton, A.J., and P.S. Lake, 2008, "Effects of Drought on Stream Insects and Its Ecological Consequences," Chapter 5 in *Aquatic Insects: Challenges to Populations*, proceedings of the Royal Entomological Society's 24th symposium, J. Lancaster and R.A. Briers (editors), CABI International, Cambridge, Mass.

Boyle, K.J., and R.C. Bishop, 1987, "Valuing Wildlife in Cost-Benefit Analyses: A Case Study Involving Endangered Species," *Water Resources Research* 23:943–950.

Brookshire, D.S., and R.C. D'Arge, 1980, "Adjustment Issues of Impacted Communities or Are Boomtowns Bad?" *Natural Resources Journal* 20:523–546.

Brown, R.B., et al., 1989, "Community Satisfaction and Social Integration in a Boomtown: A Longitudinal Analysis," *Rural Sociology* 54:568–586.

Brown, R.B., et al., 2005, "The Boom-Bust-Recovery Cycle: Dynamics of Change in Community Satisfaction and Social Integration in Delta, Utah," *Rural Sociology* 70:28–49.

Carbon County, Utah, 2004, *Carbon County Financial Statements for the Year Ended December 31, 2004*, Board of County Commissioners, Carbon County, Price, Utah.

Carbon County, Wyoming, 2006, *Financial and Compliance Report, June 30, 2006.*

Carson, R.T., et al., 1992, "Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill," *Environmental and Resource Economics* 25:257–286.

Carter, B., and W.A. Hubert, 1995, "Factors Influencing Fish Assemblages of a High-Elevation Desert Stream System in Wyoming," *Great Basin Naturalist* 55:169–173.

Cashion, W.B., 1964, *The Distribution and Quality of Oil Shale in the Green River Formation of the Uinta Basin, Utah–Colorado*, Professional Paper 501-D, U.S. Geological Survey.

Cashion, W.B., 1967, *Geology and Fuel Resources of the Green River Formation, Southeastern Uinta Basin, Utah and Colorad*o, Professional Paper 548*,* U.S. Geological Survey.

Cayan, D.R., et al., 2010, "Future Dryness in the Southwest US and the Hydrology of the Early 21st Century Drought," *Proceedings of the National Academy of Science* 107:21271–21276.

CDC (Centers for Disease Control and Prevention), 2006, *Marriage and Divorce Rates by State: 1990, 1995, 1999–2002*, National Center for Health Statistics, Division of Vital Statistics. Available at http://www.cdc.gov/nchs/data/nvss/mar%26div.pdf. Accessed July 2006.

CDC, 2011, *Chronic Wasting Disease (CWD)*, National Center for Emerging and Zoonotic Infectious Diseases, Division of High-Consequence Pathogens and Pathology. Available at http://www.cdc.gov/ncidod/dvrd/cwd. Accessed Sept. 26, 2011.

CDOT (Colorado Department of Transportation), 2004, *Colorado Highway System Traffic Volume Map*. Available at http://www.dot.state.co.us/App_DTD_DataAccess/Downloads/TrafficVolumeMaps/TVMap1.pdf. Accessed Oct. 6, 2011.

CDOW (Colorado Division of Wildlife), 2001, *Colorado's Amphibians & Reptiles, Species Status, Regulations, Information as of January 2001*, Denver, Colo. Available at http://wildlife.state.co.us/SiteCollectionDocuments/DOW/RulesRegs/HerpReport.pdf. Accessed Sept. 20, 2011.

CDOW, 2011, *Checklist of Colorado Mammals*, Denver, Colo. Available at http://wildlife.state.co.us/WildlifeSpecies/Profiles/Mammals/Pages/ChecklistofColoradoMammals.aspx. Accessed Sept. 30, 2011.

CDPHE (Colorado Department of Public Health and Environment), 2006, *Final EPA Action of 2006 303(d) List.* Available at http://www.cdphe.state.co.us/op/wqcc/SpecialTopics/303(d)/EPAfinact06303d.pdf. Accessed May 27, 2008.

CDPHE, 2009, *The Basic Standards for Ground Water*, 5 CCR 1002-41, Regulation No. 41, Water Quality Control Commission. Available at http://www.cdphe.state.co.us/regulations/wqccregs/10024basicstandardsforgroundwater.pdf. Accessed Nov. 7, 2011.

CDPHE, 2010, *Colorado's Section 303(D) List of Impaired Waters and Monitoring and Evaluation List,* Water Quality Control Commission, 5 CCR 1002-93, Regulation #93, effective April 30, 2010.

CDPHE, 2011, *Air Quality Standards, Designations and Emission Budgets*, 5 CCR 1001-14, Colorado Air Quality Control Commission. Available at http://www.cdphe.state.co.us/regulations/airregs/5CCR1001-14.pdf. Accessed Aug. 23, 2011.

Center for Native Ecosystems, 2006a, *Oil and Gas Drilling Threatens South Shale Ridge and Roan Plateau Wildflower with Extinction*. Available at http://www.nativeecosystems.org/newsroom/imported.2006-05-11.183224. Accessed July 7, 2006.

Center for Native Ecosystems, 2006b, *Endangered Species Act Protection Finally Proposed for Wildflower*. Available at http://www.nativeecosystems.org/newsroom/imported.2006-05-11.183213-1/. Accessed July 5, 2006.

Center for Native Ecosystems, 2006c, *Parachute Penstemon*. Available at http://www.native ecosystems.org/species/parachute-penstemon/. Accessed July 9, 2006.

CEQ (Council on Environmental Quality), 1997, *Environmental Justice Guidance under the National Environmental Policy Act*, Executive Office of the President, Washington, D.C. Available at http://www.whitehouse.gov/CEQ/. Accessed July 2006.

Chadwick Ecological Consultants, 2002, Progress Report for Biological Sampling of the Yellow Creek Drainage, Colorado, prepared for NorWest Mine Service, Inc., spring.

Chapman, S.S., et al., 2004, *Ecoregions of Wyoming*, U.S. Geological Survey, Reston, Va.

Chapman, S.S., et al., 2006, *Ecoregions of Colorado*, U.S. Geological Survey, Reston, Va.

Chart, T.E., and L.D. Lentsch, 1999, *Flow Effects on Humpback Chub (*Gila cypha*) in Westwater Canyon,* Utah Division of Wildlife Resources, Salt Lake City, Utah.

CIRA (Cooperative Institute for Research in the Atmosphere), 2006, *Interagency Monitoring of Protected Visual Environments*. Available at http://vista.cira.colostate.edu/IMPROVE/. Accessed June 2006.

City of Craig, Colorado, 2003, *Comprehensive Annual Financial Report, Year Ending July 31, 2003.*

City of Delta, Colorado, 2004, *City of Delta, Colorado, Financial Statements and Independent Auditor's Report, December 31, 2004*.

City of Evanston, Wyoming, 2005, *City of Evanston, Wyoming, Comprehensive Annual Financial Report, Year Ended June 30, 2005*.

City of Fruita, Colorado, 2005, *City of Fruita Financial Statements, Fiscal Year Ended December 31, 2005*.

City of Glenwood Springs, Colorado, 2004, *City of Glenwood Springs, Colorado, Financial Report, December 31, 2004*.

City of Grand Junction, Colorado, 2004, compilation of financial reports for fiscal year ended Dec. 31, 2004.

City of Green River, Wyoming, 2004, *City of Green River, Wyoming, Report of Independent Certified Public Accountants and Financial Statements, June 30, 2004*.

City of Kemmerer, Wyoming, 2005, *City of Kemmerer, Wyoming, Report of Independent Certified Public Accountants and Financial Statements, June 30, 2005*.

City of Moab, Utah, 2006, *City of Moab, Utah, Independent Auditors' Report, Basic Financial Statements, Year Ended June 30, 2006*.

City of Rawlins, Wyoming, 2005, *City of Rawlins, Wyoming, Financial Report, June 30, 2005*.

City of Rifle, Colorado, 2004, *City of Rifle, Colorado, Basic Financial Statements, December 31, 2004*.

City of Rock Springs, Wyoming, 2005, *City of Rock Springs, Wyoming, Financial and Compliance Report, June 30, 2005*.

Cloud, N.B., 2006, *Initiating Programmatic Environmental Impact Statement*, letter from Cloud (The Southern Ute Indian Tribe, Ignacio, Colo.) to S. Wisely (Bureau of Land Management, Colorado State Office, Lakewood, Colo.), March 6.

COGCC (Colorado Oil and Gas Conservation Commission), 2009, Amended Rules, 800 Series, "Aesthetic and Noise Control Regulations," 802, "Noise Abatement," April 1. Available at http://cogcc.state.co.us/rr_docs_new/FinalRulesTBLNew2.cfm. Accessed Sept. 26, 2011.

Colorado Bureau of Investigation, 2006, *Crime in Colorado—Annual Report: 2003*. Available at http://cbi.state.co.us/dr/cic2k3/agencylist.asp. Accessed July 2006.

Colorado Field Ornithologists, 2008, *Checklist of the Birds of Garfield County*. Available at http://www.coloradocountybirding.com/checklists/checklist.php?id=24&flag=pdf&name= Garfield. Accessed Sept. 21, 2011.

Colorado Field Ornithologists, 2010, *Checklist of the Birds of Rio Blanco County*. Available at http://www.coloradocountybirding.com/checklists/checklist.php?id=53&flag=pdf&name= RioBlanco. Accessed Sept. 21, 2011.

Colorado Field Ornithologists, 2011, *Checklist of the Birds of Colorado*. Available at http://www.coloradocountybirding.com/checklists/checklist.php?flag=pdf&name=Colorado. Accessed Sept. 21, 2011.

Colorado Rare Plant Technical Committee, 1999, *Colorado Rare Plant Field Guide*. Available at http://www.cnhp.colostate.edu/rareplants/cover.html. Accessed May 17, 2008.

Colorado State Demography Office, 2007, *State Demography Office*. Available at http://www.dola.state.co.us/demog/. Accessed March 2007.

Colorado State Parks, 2006a, home page. Available at http://parks.state.co.us.

Colorado State Parks, 2006b, *Natural Areas Program.* Available at http://parks.state.co.us/ cnap/Natural_Areas/NA%20pages/dudley.htm. Accessed July 1, 2006.

Cook, N., et al., 2010, "Persistence of Colorado River Cutthroat Trout Populations in Isolated Headwater Streams of Wyoming," *Transactions of the American Fisheries Society* 139:1500–1510.

Cornell Laboratory of Ornithology, 2006, *All About Birds, Bird Guide—Whooping Crane*. Available at http://www.birds.cornell.edu/AllAboutBirds/BirdGuide/Whooping_Crane_ dtl.html. Accessed July 15, 2006.

Cortese, C.F., 1982, "The Impacts of Rapid Growth on Local Organizations and Community Services," pp. 115–136, in *Coping with Rapid Growth in Rural Communities,* B. Weber and R. Howell (editors), Westview Press, Boulder, Colo.

Cortese, C.F., and B. Jones, 1977, "The Sociological Analysis of Boom Towns," *Western Sociological Review* 8:76–90.

Cowardin, L., et al., 1979, *Classification of Wetlands and Deepwater Habitats of the United States*, FWS/OBS-79, U.S. Fish and Wildlife Service.

CPC (Center for Plant Conservation), 2006a, *CPC National Collection Plant Profile,* Ranunculus aestivali. Available at http://www.centerforplantconservation.org/ASP/CPC_ViewProfile.asp?CPCNum=3705. Accessed July 16, 2006.

CPC, 2006b, *CPC National Collection Plant Profile,* Schoenocrambe barnebyi. Available at http://www.centerforplantconservation.org/ASP/CPC_ViewProfile.asp?CPCNum=3871. Accessed July 17, 2006.

CPC, 2006c, *CPC National Collection Plant Profile,* Lesquerella congesta. Available at http://www.centerforplantconservation.org/ASP/CPC_ViewProfile.asp?CPCNum=6371. Accessed July 8, 2006.

CPC, 2006d, *CPC National Collection Plant Profile,* Physaria obcordata. Available at http://www.centerforplantconservation.org/ASP/CPC_ViewProfile.asp?CPCNum=3447. Accessed July 1, 2006.

CPC, 2006e, *CPC National Collection Plant Profile*, Cycladenia humilis *var.* jonesii. Available at http://www.centerforplantconservation.org/ASP/CPC_ViewProfile.asp?CPCNum=1204. Accessed July 8, 2006.

CPC, 2006f, *CPC National Collection Plant Profile,* Erigeron maguirei *var.* maguirei. Available at http://www.centerforplantconservation.org/ASP/CPC_Viewprofile.asp?CPCNum=1654. Accessed July 18, 2006.

CPC, 2006g, *CPC National Collection Plant Profile,* Carex specuicola. Available at http://www.centerforplantonservation.org/ASP/CPC_ViewProfile.asp?CPCNum =789. Accessed July 18, 2006.

CPC, 2006h, *CPC National Collection Plant Profile,* Schlerocactus wrightiae. Available at http://www.centerforplantconservation.org/ASP/CPC_ViewProfile.asp?CPCNUM=3891. Accessed July 8, 2006.

CPC, 2010, *CPC National Collection Plant Profile*, Phacelia argillacea. Available at Profile,http://www.centerforplantconservation.org/collection/CPC_ViewProfile.asp?CPCNum=3340. Accessed Sept. 27, 2011.

CRBSCF (Colorado River Basin Salinity Control Forum), 2005, *2005 Review, Water Quality Standards for Salinity, Colorado River System*, Oct.

CRCT Conservation Team, 2006, *Conservation Agreement for Colorado River Cutthroat Trout* (Oncorhynchus clarkii pleuriticus) *in the States of Colorado, Utah, and Wyoming*, Colorado Division of Wildlife, Fort Collins, Colo.

Culburtson, W.C., and Pitman, J.K., 1973, "Oil Shale in United States Mineral Resources," Professional Paper 820 in *United States Mineral Resources*, D.A. Probst and W.P. Pratt (editors), U.S. Geological Survey.

CWCB (Colorado Water Conservation Board), 2002, *Yampa and White River Basin Facts*. Available at http://cwcb.state.co.us/Board/Fact_Sheets/YampaW_fs.pdf. Accessed May 25, 2006.

CWCB, 2004, *Statewide Water Supply Initiative*, Colorado Department of Natural Resources, Denver, Colo., Nov.

CWS and USFWS (Canadian Wildlife Service and U.S. Fish and Wildlife Service), 2007, *International Recovery Plan for the Whooping Crane*. Ottawa: Recovery of Nationally Endangered Wildlife (RENEW), and U.S. Fish and Wildlife Service, Albuquerque, NM.

Czyzewski, G., 2000, "The Piceance Creek Basin," pp. 63–66, in *Colorado Ground-Water Atlas: Colorado Ground-Water Association*, A. Aikin et al. (editors), Lakewood, Colo.

Delta County, Colorado, 2005, *Delta County, Colorado, Basic Financial Statements, Year Ended December 31, 2005*, Board of Commissioners, Delta County, Delta, Colo.

Dixon, M., 1978, *What Happened to Fairbanks? The Effects of the Trans-Alaska Oil Pipeline in the Community of Fairbanks, Alaska*, Westview Press, Boulder, Colo.

DOE (U.S. Department of Energy), 1982, *Final Programmatic Environmental Impact Statement on Development Policy Options for the Naval Oil Shale Reserves in Colorado*, Environmental Protection Assistant Secretary, Safety and Emergency Preparedness, Office of Naval Petroleum and Oil Shale Reserves.

DOI (U.S. Department of the Interior), 1973, *Final Environmental Statement for the Prototype Oil Shale Leasing Program, Volume I of VI, Regional Impacts of Oil Shale Development*, Washington, D.C.

DOI, 1994, "Natural Resource Damage Assessments: Final Rule," *Federal Register*, No. 59, 14261–14288.

DOI, 2005, "Salinity Control Program," in *Quality of Water: Colorado River Basin, Progress Report No. 22, Final Draft.* Available at http://www.usbr.gov/uc/progact/salinity/index.html. Accessed May 25, 2006.

Duchesne County, Utah, 2004, *Duchesne County Financial Statements, Year Ending December 31, 2004*, County Commissioners, Duchesne County, Duchesne, Utah.

Dunne, T., and L.B. Leopold, 1978, *Water in Environmental Planning*, W.H. Freeman and Company, New York, N.Y.

Dyni, J.R., 2003, "Geology and Resources of Some World Oil-Shale Deposits," *Oil Shale* 20(3):193–252.

Ebi, K.L., et al., 2007, *Regional Impacts of Climate Change: Four Case Studies in the United States*, prepared for Pew Center on Global Climate Change, Dec. Available at http://www.pewclimate.org/docUploads/Regional-Impacts-FullReport.pdf. Accessed Oct. 10, 2011.

Emery County, Utah, 2004, *Emery County Financial Statements December 31, 2004*, Emery County Clerk/Auditor, Castle Dale, Utah.

Emmerich, J., 2011, personal communication from Emmerich (Bureau of Land Management, Cheyenne, Wyo.) to M. Grippo (Argonne National Laboratory, Argonne, Ill.), Nov. 10.

England, J.L., and S.L. Albrecht, 1984, "Boomtowns and Social Disruption," *Rural Sociology* 49:230–246.

EPA (U.S. Environmental Protection Agency), 1974, *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, 550/9-74-004, Office of Noise Abatement and Control, March. Available at http://www.nonoise.org/library/levels74/levels74.htm. Accessed Sept. 26, 2011.

EPA, 2010, *Climate Change Indicators in the United States,* EPA 430-R-10-007, Washington, D.C., April. Available at http://www.epa.gov/climatechange/indicators/pdfs/ClimateIndicators_full.pdf. Accessed Nov. 16, 2011.

EPA, 2011a, *State of Knowledge*. Available at http://www.epa.gov/climatechange/science/stateofknowledge.html, last updated April 14, 2011. Accessed Oct. 9, 2011.

EPA, 2011b, *National Ambient Air Quality Standards (NAAQS)*. Available at http://www.epa.gov/air/criteria.html, last updated Aug. 4, 2011. Accessed Aug. 22, 2011.

EPA, 2011c, *The Green Book Nonattainment Areas for Criteria Pollutants*. Available at http://www.epa.gov/oaqps001/greenbk/, last updated July 22, 2011. Accessed Aug. 23, 2011.

EPA, 2011d, *AirData: Monitor Values Report—Criteria Air Pollutants*. Available at http://www.epa.gov/oar/data/geosel.html. Accessed Sept. 21, 2011.

EPA, 2011e, *Clean Air Status and Trends Network (CASTNET)*. Available at http://java.epa.gov/castnet/. Accessed Sept. 23, 2011.

Everard M., 1996, "The Importance of Periodic Droughts for Maintaining Diversity in the Freshwater Environment, *Freshwater Forum* 7:33–50.

Exxon Mobil, 2006, *Exxon Mobil Piceance Development Project Environmental Assessment. Socioeconomic Technical Report*, prepared for Bureau of Land Management, White River Field Office, May.

FBI (Federal Bureau of Investigation), 2011, *Crime in the United States: 2009*. Available at http://www.fbi.gov/about-us/cjis/ucr/crime-in-the-u.s/2010/crime-in-the-u.s.-2010.

Feeney, D., et al., 2004, *Big Game Migration Corridors in Wyoming*, University of Wyoming, Wyoming Open Spaces Initiative, Laramie, Wyo. Available at http://www.uwyo.edu/ openspaces/docs/MigrationCorridors.pdf. Accessed April 24, 2006.

Fire Departments Network, 2011, *Fire Departments by State*. Available at http://www. firedepartments.net.

Frankel, A.D., et al., 2002, *Documentation for the 2002 Update of the National Seismic Hazard Maps*, Open-File Report 02-420, U.S. Geological Survey. Available at http://earthquake. usgs.gov/ research/ hazmaps/products_data/48_States/index.php. Accessed July 5, 2006.

Freudenburg, W.R., 1984, "Boomtown's Youth: The Differential Impacts of Rapid Community Growth on Adolescents and Adults," *American Sociological Review* 49:697–705.

Freudenburg, W.R., 1986, "The Density of Acquaintanceship: An Overlooked Variable in Community Research?" *American Journal of Sociology* 92:27–63.

Freudenburg, W.R., and R.E. Jones, 1991, "Criminal Behavior and Rapid Community Growth: Examining the Evidence," *Rural Sociology* 56:619–645.

Freudenburg, W.R., et al., 1982, "Mental Health Consequences of Rapid Growth: A Report from the Longitudinal Study of Boom Town Mental Health Impacts," *Journal of Health and Human Resources Administration* 4:334–352.

Garfield County, Utah, 2004, *Garfield County, Utah, Financial Statements and Supplementary Information with Independent Auditor's Report, Year Ended December 31, 2004*, Board of County Commissioners, Panguitch, Utah.

Gilmore, J.S., 1976, "Boom Towns May Hinder Energy Resource Development," *Science* 191:535–540.

Gilmore, J.S., and M.K. Duff, 1975, *Boomtown Growth Management,* Westview Press, Boulder, Colo.

GISS (Goddard Institute for Space Studies), 2011, *GISS Surface Temperature Analysis*, National Aeronautics and Space Administration (NASA). Available at http://data.giss.nasa.gov/gistemp/ graphs, last updated Sept. 12, 2011. Accessed Oct. 10, 2011.

Glassett, J.M., and J.A. Glassett, 1976, *The Production of Oil from Intermountain West Tar Sands Deposits, Final Report to United States Department of the Interior, Bureau of Mines*, Eyring Research Institute, Provo, Utah.

Glover, K.C., 1996, *Ground-Water Flow in the Duchesne River–Uinta Aquifer, Uinta Basin, Utah and Colorado*, Water-Resources Investigations Report 92-4161, U.S. Geological Survey.

Glover, K.C., et al., 1998, *Geohydrology of Tertiary Rocks in the Upper Colorado River Basin in Colorado, Utah, and Wyoming, Excluding the San Juan Basin*, U.S. Geological Survey, Water-Resources Investigations Report 96-4105.

Gold, R.L., 1982, "Commentary on Local Social Disruption and Western Energy-Development: A Critical Review by Wilkinson, K.P. et al.," *Pacific Sociological Review* 25:349–356.

Goodrich, S., and E. Neese, 1986, *Uinta Basin Flora*, USDA Forest Service – Intermountain Region, in cooperation with USDA Forest Service Ashley National Forest and DOI Bureau of Land Management.

Grand County, Utah, 2004, *Grand County Financial Statements for the Year Ended December 31, 2004*, Grand County Council, Moab, Utah.

Greider, T., and R.S. Krannich, 1985, "Neighboring Patterns, Social Support and Rapid Growth: A Comparison Analysis from Three Western Communities," *Sociological Perspectives* 28:51–70.

Greider, T., et al., 1991, "Local Identity, Solidarity, and Trust in Changing Rural Communities," *Sociological Focus* 24:263–282.

Gryska, A.D., and W.A. Hubert, 1997, "Observations on the Reproduction, Sources of Mortality, and Diet of the Kendall Warm Springs Dace," *Great Basin Naturalist*57:338–342.

Gulliford, A., 1989, *Boomtown Blues: Colorado Oil Shale, 1885–1985*, University of Colorado Press, Boulder, Colo.

Gutermuth, F.B., et al., 1994, "Collection of Age-0 Razorback Suckers (*Xyrauchen texanus*) in the Lower Green River, Utah," *Southwestern Naturalist* 39:389–391.

Hahn, W.F., and C.A. Jessen, 2001, *Green River Basin Water Plan, Technical Memorandum: Available Ground Water Determination*. Available at http://waterplan.state.wy.us/plan/green/techmemos/techmemos.html. Accessed May 25, 2006.

Hamman, R.L, 1981, "Spawning and Culture of Colorado Squawfish in Raceways," *Progressive Fish-Culturist* 43:173–177.

Harris, C.M. (editor), 1991, *Handbook of Acoustical Measurements and Noise Control*, 3rd ed., McGraw-Hill Book Company, New York, N.Y.

Hatton, T., 2000, "White River Basin," pp. 41–43, in *Colorado Ground-Water Atlas*, A. Aikin et al. (editors), Colorado Ground-Water Association, Lakewood, Colo.

Haynes, C.M., et al., 1984, "Larval Colorado Squawfish *(Ptychocheilus lucius)* in the Upper Colorado River Basin, Colorado, 1979–1981," *Southwestern Naturalist* 29:21–33.

Hendrickson, D.A., 1993, *Progress Report on a Study of the Utility of Data Obtainable from Otoliths to Management of Humpback Chub* (Gila cypha) *in the Grand Canyon,* Arizona Game and Fish Department, Phoenix, Ariz.

Hirsch, C.L., et al., 2006, *Range-wide Status of Colorado River Cutthroat Trout (*Oncorhynchus clarkii pleuriticus*): 2005*, Colorado River Cutthroat Trout Conservation Team Report, Colorado Division of Wildlife, Ft. Collins, Colo.

Holmes, W.F., and Kimball, B.A., 1987, *Ground Water in the Southeastern Uinta Basin, Utah and Colorado*, Water Supply Paper 2248, U.S. Geological Survey.

Hood, J.W., and T.W. Danielson, 1981, *Bedrock Aquifers in the Lower Dirty Devil River Basin Area, Utah, with Special Emphasis on the Navajo Sandstone*, Technical Publication No. 68, Utah Department of Natural Resources.

Hood, J.W., and F.K. Fields, 1978, *Water Resources of the Northern Uinta Basin Area, Utah and Colorado, with Special Emphasis on Ground-Water Supply*, Technical Publication No. 62, Utah Department of Natural Resources.

Howe, F.P., and M. Hanberg, 2000, *Willow Flycatcher and Yellow-Billed Cuckoo Surveys along the Green and San Juan Rivers in Utah, 2000*, Publication 00-31, Utah Division of Wildlife Resources, Salt Lake City, Utah.

Hranac, K., 2000, "Ground-Water Quality," pp. 9–13, in *Colorado Ground-Water Atlas*, A. Aikin et al. (editors), Colorado Ground-Water Association, Lakewood, Colo.

Hughes, J.M., 1999, "Yellow-Billed Cuckoo," in *The Birds of North America*, No. 418, A. Poole and F. Gill (editors), Cornell Laboratory of Ornithology and the Academy of Natural Sciences.

Hyde, M., 2011, personal communication from Hyde (Duchesne County), to S. Thompson (Bureau of Land Management), Nov. 4.

IPCC (Intergovernmental Panel on Climate Change), 2007, *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Interngovernmental Panel on Climate Change*, S. Solomon et al. (eds.). Available at http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html.

Jirovec, R., 1979, "Preparing a Boom Town for the Impact of Rapid Growth," pp. 79–90, in *BoomTowns and Human Services,* J. Davenport and J. Davenport (editors), University of Wyoming Press, Laramie, Wyo.

Kelly, I.T., and C.S. Fowler, 1986, "Southern Paiute," pp. 368-397, in *Handbook of North American Indians, Vol. 11 Great Basin,* W.L. d'Azevedo (editor), Smithsonian Institution, Washington, D.C.

Koontz, L., and J. Loomis, 2005, *Economic Importance of Elk Hunting in Jackson Hole, Wyoming*, Open-File Report 2005-1183, U.S. Geological Survey, Fort Collins Science Center, Fort Collins, Colo.

Kotamarthi, V.R., and D.J. Holdridge, 2007*, Process-Scale Modeling of Elevated Wintertime Ozone in Wyoming*, ANL/EVS/R-07/7, prepared by Environmental Science Division, Argonne National Laboratory, for BP America, Dec. Available at http://www.ipd.anl.gov/anlpubs/2008/01/60757.pdf. Accessed Sept. 23, 2011.

Krannich, R.S., and T. Greider, 1984, "Personal Well-Being in Rapid Growth and Stable Communities: Multiple Indicators and Contrasting Results," *Rural Sociology* 49:541–552.

Krannich, R., et al., 1989, "Fear of Crime in Rapidly Changing Communities: A Longitudinal Analysis," *Rural Sociology* 54:195–212.

Lake, P.S., 2003, "Ecological Effects of Perturbation by Drought in Flowing Waters," *Freshwater Biology* 48:1161–1172.

Lamm, R.D., and McCarthy, M., 1982, *The Angry West: A Vulnerable Land and Its Future*, Houghton Mifflin Company, Boston, Mass.

Lantz, A., and R. McKeown, 1977, *Rapid Growth and the Impact on Quality of Life in Rural Communities: A Case Study*, Denver Research Institute, University of Denver, Denver, Colo.

Lentsch, L.D., et al., 1996, *Options for Selective Control of Nonnative Fishes in the Upper Colorado River Basin*, Publication No. 96-14, Utah Division of Wildlife Resources, Salt Lake City, Utah.

Lentsch, L.D., et al., 2000, *The White River and Endangered Fish Recovery: A Hydrological, Physical, and Biological Synopsis*, Publication No. 00-37, Utah Division of Wildlife Resources, Salt Lake City, Utah, Sept.

Lincoln County, Wyoming, 2006, *Lincoln County Financial Statements, June 30, 2006*, Board of County Commissioners, Kemmerer, Wyo.

Lincoln, F.C., et al., 1998, *Migration of Birds*, Circular 16, U.S. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C., Jamestown, N.D., Northern Prairie Wildlife Research Center Online. Available at http://www.npwrc.usgs.gov/resource/birds/migratio/index.htm (Version 02APR 2002). Accessed Sept. 26, 2006.

Lindskov, K.L., and B.A. Kimball, 1982, *Quantity and Quality of Streamflow in the Southeastern Uinta Basin, Utah and Colorado*, Water Supply Paper 2224, U.S. Geological Survey.

Lindskov, K.L., and B.A. Kimball, 1984, *Water Resources and Potential Hydrologic Effects of Oil-Shale Development in the Southeastern Uinta Basin, Utah and Colorado*, Professional Paper 1307, U.S. Geological Survey.

Little, R.I., 1977, "Some Social Consequences of Boom Towns," *North Dakota Law Review* 53:401–425.

Lockhart, J.M., et al., 2006, "A Historical Perspective on Recovery of the Black-footed Ferret and the Biological and Political Challenges Affecting Its Future," in *Recovery of the Black-footed Ferret: Progress and Continuing Challenges, Proceedings of the Symposium on the Status of the Black-Footed Ferret and Its Habitat,* Jan. 28–29, 2004, Fort Collins, Colo., Scientific Investigations Report 2005–5293, J.E. Roelle et al. (eds), U.S. Geological Survey, Reston, Va.

Loomis, J., 2000, *Economic Values of Wilderness Recreation and Passive Use: What We Think We Know at the Beginning of the 21st Century,* U.S. Forest Service Proceedings, RMRS-P-15_VOL-2. 2000. Available at http://www.fs.fed.us/rm/pubs/rmrs_p015_2/rmrs_p015_2_005_013.pdf. Accessed Oct. 7, 2011.

Loomis, J., and R. Walsh, 1997, *Recreation Economic Decisions: Comparing Benefits and Costs*, Venture Press, State College, Pa.

Martineau, D., 2006, *Oil Shale and Tar Sands Programmatic EIS,* letter from Martineau (The Paiute Indian Tribe of Utah, Cedar City, Utah) to G. Terland (Bureau of Land Management, Utah State Office, Salt Lake City, Utah), May 25.

Martinez, P.J., 2011, "Invasive Crayfish in a High Desert River: Implications of Concurrent Invaders and Climate Change," *Aquatic Invasions*, in press.

Martinez, P.J., et al., 1994, "Fish Species Composition before and after Construction of a Mainstem Reservoir on the White River, Colorado." *Environmental Biology of Fishes* 40:227–239.

Mason, J.P., and K.A. Miller, 2004, *Water Resources of Sweetwater County, Wyoming*, Scientific Investigations Report 2004-5214, U.S. Geological Survey, Reston, Va.

McAda, C.W., 2003, *Flow Recommendations to Benefit Endangered Fishes in the Colorado and Gunnison Rivers*, final report to Upper Colorado River Endangered Fish Recovery Program, July.

Mesa County, Colorado, 2003, *Comprehensive Annual Financial Report, Mesa County, Colorado, for the Fiscal Year Ended December 31, 2003*.

Miller, A.S., and W.A. Hubert, 1990, *Compendium of Existing Knowledge for Use in Making Habitat Management Recommendations for the Upper Colorado River Basin*, final report of the U.S. Fish and Wildlife Service, Wyoming Cooperative Fish and Wildlife Research Unit, to the Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Miller, N.P., 2002, "Transportation Noise and Recreational Lands," in *InterNoise 2002, Proceedings of the 2002 International Congress and Exposition on Noise Control Engineering*, Aug. 19–21, Dearborn, Mich.

Minckley, W.L., 1973, *Fishes of Arizona*, Arizona Game and Fish Department, Phoenix, Ariz.

Minckley, W.L., et al., 1991, "Management toward Recovery of the Razorback Sucker," in *Battle against Extinction: Native Fish Management in the American West,* W.L. Minckley and J.E. Deacon (editors), University of Arizona Press, Tucson, Ariz.

Minckley, W.L., et al., 2003, "A Conservation Plan for Native Fishes of the Lower Colorado River," *BioScience* 53: 219–234.

Modde, T., 1996, "Juvenile Razorback Sucker (*Xyrauchen texanus*) in a Managed Wetland Adjacent to the Green River," *Great Basin Naturalist* 56:375–376.

Modde, T., 1997, *Fish Use of Old Charley Wash: An Assessment of Floodplain Wetland Importance to Razorback Sucker Management and Recovery*, U.S. Fish and Wildlife Service, Vernal, Utah.

Modde, T., and G.B. Haines, 1996, "Brook Stickleback (*Culaea inconstans* [Kirkland 1841]), a New Addition to the Upper Colorado River Basin Fish Fauna," *Great Basin Naturalist* 56:281.

Modde, T., and D.B. Irving, 1998, "Use of Multiple Spawning Sites and Seasonal Movements by Razorback Suckers in the Middle Green River, Utah," *North American Journal of Fisheries Management* 18:318–326.

Modde, T., and C. Keleher, 2003, *Flow Recommendations for the Duchesne River with a Synopsis of Information Regarding Endangered Fishes*, U.S. Fish and Wildlife Service, Vernal, Utah.

Modde, T., and E.J. Wick, 1997, *Investigations of Razorback Sucker Distribution, Movements and Habitats Used during Spring in the Green River, Utah*, U.S. Fish and Wildlife Service, Vernal, Utah.

Modde, T., et al., 1996, "Population Status of the Razorback Sucker in the Middle Green River," *Conservation Biology* 10:110–119.

Moen, E., et al. (editors), 1981, *Women and the Social Cost of Energy Development: Two Colorado Case Studies,* Westview Press, Boulder, Colo.

Moffat County, Colorado, 2005, *Moffat County, Colorado, Craig, Colorado, Financial Statements, December 31, 2005*.

Morris, R.E., et al., 2009, "Simulation of Wintertime High Ozone Concentrations in Southwestern Wyoming," presented at the *8th Annual CMAS Conference*, Chapel Hills, N.C., Oct. 19–21. Available at http://www.cmascenter.org/conference/2009/abstracts/morris_simulation_wintertime_2009.pdf. Accessed Sept. 23, 2011.

Murdock, S.H., and E.C. Schriner, 1979, "Community Service Satisfaction and Stages of Community Development: An Examination of Evidence from Impacted Communities," *Journal of the Community Development Society* 10:109–124.

Murphey, P.C., and D. Daitch, 2007, unpublished information, Argonne National Laboratory, Argonne, Ill.

Muth, R.T., and T.P. Nesler, 1993, *Associations among Flow and Temperature Regimes and Spawning Periods and Abundance of Young of Selected Fishes, Lower Yampa River, Colorado, 1980–1984,* final report, prepared by Colorado State University Larval Fish Laboratory for Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Muth, R.T., and D.E. Snyder, 1995, "Diets of Young Colorado Squawfish and Other Small Fish in Backwaters of the Green River, Colorado and Utah," *Great Basin Naturalist* 55:95–104.

Muth, R.T., et al., 1998, *Reproduction and Early Life History of Razorback Sucker in the Green River, Utah and Colorado, 1992–1996*, Colorado State University Larval Fish Laboratory, Fort Collins, Colo.

Muth, R.T., et al., 2000, *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam*, final report, Upper Colorado River Endangered Fish Recovery Program, Denver, Colo., Sept.

NADP (National Atmospheric Deposition Program), 2011, home page. Available at http://nadp.sws.uiuc.edu/. Accessed Sept. 23, 2011.

Natchees, M., 2007, *Oil Shale Development Programmatic Environmental Impact Statement, Unita Basin, Utah,* letter from Natchees (The Ute Indian Tribe of the Uintah and Ouray Reservation, Fort Duchesne, Utah) to S. Thompson (Bureau of Land Management State Office, Lakewood, Colo.), April 11.

National Parks Conservation Association, 2006, *California Condor*. Available at http://www.npca.org/wildlife_protection/wildlife_facts/condor.html. Accessed July 13, 2006.

NatureServe, 2011, *NatureServe Explorer: An Online Encyclopedia of Life*, Version 7.1, Arlington, Va. Available at http://www.natureserve.org/explorer. Accessed Sept. 26, 2011.

NCDC (National Climatic Data Center), 2011a, *Integrated Surface Data (ISD), DS3505 format*, database, Asheville, N.C. Available at ftp://ftp3.ncdc.noaa.gov/pub/data/noaa. Accessed Aug. 23, 2011.

NCDC, 2011b, *Storm Events*, National Oceanic and Atmospheric Administration (NOAA) Satellite and Information Service. Available at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms. Accessed Aug. 25, 2011.

NCES (National Center for Education Statistics), 2011, *Search for Public School Districts*, U.S. Department of Education. Available at http://www.nces.ed.gov/ccd/districtsearch.

Nelson, J.S., et al., 2004, *Common and Scientific Names of Fishes from the United States, Canada, and Mexico*, 6th ed., American Fisheries Society, Special Publication 29, Bethesda, Md.

Nelson, M., and R.P. Guralnick, 2007, *A Field Guide to the Freshwater Mollusks of Colorado*. Colorado Division of Wildlife, Denver, Colo.

Nesler, T.P., et al., 1988, "Evidence for Baseline Flow Spikes as Spawning Cues for Colorado Squawfish in the Yampa River, Colorado," *American Fisheries Society Symposium* 5:68–79.

Nicholoff, S.H., 2003, *Wyoming Bird Conservation Plan, Version 2.0*, Wyoming Partners in Flight, Wyoming Game and Fish Department, Lander, Wyo. Available at http://www.blm.gov/wildlife/plan/WY/Wyoming%20Bird%20Conservation%20Plan.htm. Accessed Sept. 26, 2006.

NNHP (Nevada Natural Heritage Program), 2001, Spiranthes diluvialis Sheviak*, Ute Ladies'-Tresses,* Rare Plant Fact Sheet.

NOAA (National Oceanic and Atmospheric Administration), 2010, *State of the Climate in 2009*, D.S. Arndt et al. (editors), Special Supplement to the *Bulletin of the American Meteorological Society*, Vol. 91, No. 7, July. Available at http://www1.ncdc.noaa.gov/pub/data/cmb/bams-sotc/climate-assessment-2009-lo-rez.pdf. Accessed Nov. 16, 2011.

NRC (National Research Council), 1992, *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, National Academy Press, Washington, D.C.

NWCC (National Wind Coordinating Committee), 2002, *Permitting of Wind Energy Facilities: A Handbook*, prepared by the NWCC Siting Subcommittee, Aug. Available at http://www.nationalwind.org/assets/publications/permitting2002.pdf. Accessed Sept. 26, 2011.

Orabona, A., et al., 2009, *Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming*, Wyoming Game and Fish Department, Nongame Program, Lander, Wyo.

O'Rourke, D., et al., 2007, *Class I Cultural Resource Overview for Oil Shale and Tar Sands Areas in Colorado, Utah, and Wyoming*, prepared by Argonne National Laboratory, Argonne, Ill., for U.S. Department of the Interior, Bureau of Land Management, Nov.

Osmundson, D.B., and K.P. Burnham, 1996, *Status and Trends of Colorado Squawfish in the Upper Colorado River,* final report, prepared by U.S. Fish and Wildlife Service, Grand Junction, Colo., for Upper Colorado River Endangered Fish Recovery Program, Denver, Colo.

Osmundson, D.B., and L.R. Kaeding, 1989, *Studies of Colorado Squawfish and Razorback Sucker Use of the "15-Mile Reach" of the Upper Colorado River as Part of Conservation Measures for the Green Mountain and Ruedi Reservoir Water Sales*, U.S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colo.

Ott, R., 2010, *Perspectives on Ute Ethnohistory in West Central Colorado,* prepared by Dominguez Archaeological Research Group for the Ute Indian Tribe of the Uintah and Ouray Reservation, the Ute Mountain Ute Tribe, the Southern Ute Tribe, and Bureau of Land Management Colorado State Office, Dec. 6.

Parrish, J.R., et al., 2002, *Utah Partners in Flight, Avian Conservation Strategy, Version 2.0*, Utah Partners in Flight Program, Utah Division of Wildlife Resources, Salt Lake City, Utah. Available at http://www.wildlife.utah.gov/publications/pdf/utah_partners_in_flight.pdf. Accessed Sept. 26, 2006.

Peterson, D.A., 1988, *Streamflow Characteristics of the Green, Bear, and Snake River Basins, Wyoming, through 1984*, Water-Resources Investigations Report 87-4022, U.S. Geological Survey.

Pope, C., and J. Jones, 1990, "Value of Wilderness Designation in Utah," *Journal of Environmental Management*, 30:157–174.

Platania, S.P., et al., 1991, "Status of Colorado Squawfish and Razorback Sucker in the San Juan River, Colorado, New Mexico, and Utah," *Southwestern Naturalist* 36:147–150.

Price Municipal Corporation, Utah, 2005, *Price Municipal Corporation, Basic Financial Statements for the Year Ended June 30, 2005*, Price, Utah.

Price, D., and L.L. Miller, 1975, *Hydrologic Reconnaissance of the Southern Uinta Basin, Utah and Colorado*, Technical Publication No. 49, Utah Department of Natural Resources.

Propst, D.L., et al., 2008, "Natural Flow Regimes, Nonnative Fishes, and Native Fish Persistence in Arid-Land River Systems," *Ecological Applications* 18:1236–1252.

Radbruch-Hall, D.H., et al., 1982, *Landslide Overview Map of the Conterminous United States*, Professional Paper 1183, U.S. Geological Survey. Available at http://pubs.usgs.gov/ pp/p1183/ pp1183.html. Accessed July 5, 2006.

Raftovich, R.V., et al., 2011, *Migratory Bird Hunting Activity and Harvesting during the 2009 and 2010 Hunting Seasons*, U.S. Fish and Wildlife Service, Laurel, Md. Available at http://www.fws.gov/migratorybirds/NewReportsPublications/HIP/HuntingStatistics/migratory%20bird%20hunting%20activity%20and%20harvest%20during%20the%202009%20and%202010%20hunting%20seasons.pdf. Accessed Sept. 23, 2011.

Rahel, F.J., and J.D. Olden, 2008, "Assessing the Effects of Climate Change on Aquatic Invasive Species," *Conservation Biology* 22:521–533.

Rasmussen, W., 2008, personal communication from Rasmussen (Exxon Mobil, Houston, Texas) to T. Allison (Argonne National Laboratory, Argonne, Ill.), March.

Ray, A., et al., 2008, *Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation*, Colorado Water Conservation Board, Colo. Available at http://cwcb.state.co.us/public-information/publications/Documents/ReportsStudies/. Accessed Oct. 7, 2011.

Recreation.gov, 2006, home page. Available at http://www.recreation.gov. Accessed Oct. 7, 2011.

Reed, A.D., and M.D. Metcalf, 1999, *Colorado Prehistory: A Context for the Northern Colorado River Basin,* Colorado Council of Professional Archaeologists, Denver, Colo.

Repplier, F.N., et al., 1981, *Atlas of Ground Water Quality in Colorado*, Colorado Geological Survey, Denver, Colo.

Rinne, J.N., et al., 1986, "The Role of Hatcheries in the Management and Recovery of Threatened and Endangered Fishes," pp. 271–285, in *Fish Culture in Fisheries Management*, R.H. Stroud (editor), American Fisheries Society, Bethesda, Md.

Rio Blanco County, Colorado, 2002, Article X: "Standards," Section 260: "Standard for Noise and Vibration," in *Rio Blanco County Land Use Resolution*. Available at http://www.co.rio-blanco.co.us/development/pdf/Section%20260%20Noise.pdf. Accessed Sept. 26, 2011.

Rio Blanco County, Colorado, 2005, *Summary of Levies and Values, Rio Blanco County, Colorado, 2005*, Office of County Treasurer, Meeker, Colo.

Robinson, A.T., et al., 1998, "Dispersal of Larval Fishes in a Regulated River Tributary," *Transactions of the American Fisheries Society* 127:772–786.

Robson, S.G., and G.J. Saulnier, 1981, *Hydrogeochemistry and Simulated Solute Transport*, Piceance Basin, Northwestern Colorado, U.S. Geological Survey Professional Paper 1196.

Roehler, H.W., 1992, *Description and Correlation of Eocene Rocks in Stratigraphic Reference Sections for the Green River and Washakie Basins, Southwest Wyoming*, Professional Paper 506, U.S. Geological Survey.

Roosevelt City Corporation, Utah, 2005, *Roosevelt City Corporation, Duchesne County, Utah, Annual Financial Report for the Year Ended June 30, 2005*.

Ruediger, B., et al., 2000, *Canada Lynx Conservation Assessment and Strategy*, U.S. Forest Service, U.S. Department of Agriculture; U.S. Fish and Wildlife Service, Bureau of Land Management, and National Park Service, U.S. Department of the Interior, Missoula, Mont.

SAMHSA (Substance Abuse and Mental Health Services Administration), 2006, *2005 State Estimates of Substance Use and Mental Health, 2004 and 2005*, Office of Applied Studies, U.S. Department of Health and Human Services. Available at: http://oas.samhsa.gov/2k5State/AppB.htm#TabB.16. Accessed Aug. 2007.

San Juan County, Utah, 2004, *San Juan County, Independent Auditor's Report, Basic Financial Statements, Year Ended December 31, 2004*, San Juan County Clerk Auditor, Monticello, Utah.

Saunders, S., et al., 2008, *Hotter and Drier: The West's Changed Climate*, prepared for the Rocky Mountain Climate Organization (RMCO) and the Natural Resources Defense Council (NRDC), March. Available at http://www.nrdc.org/globalwarming/west/west.pdf. Accessed Oct. 10, 2011.

Sawyer, H., et al., 2005, "Mule Deer and Pronghorn Migration in Western Wyoming," *Wildlife Society Bulletin* 33(4):1266–1273.

Schulze, W.D., and D.S. Brookshire, 1983, "The Economic Benefits of Preserving Visibility in the National Park Lands of the Southwest," *Natural Resources Journal* 23:149–173.

Seyfrit, C.L., and N.C. Sadler-Hammer, 1988, "Social Impact of Rapid Energy Development on Rural Youth: A Statewide Comparison," *Society and Natural Resources* 1:57–67.

Shimkin, D.B., 1947, *Wind River Shoshone Ethnogeography,* University of California Anthropological Records 5(4), Berkeley, Calif.

Shimkin, D.B., 1986, "Eastern Shoshone," pp. 308–335, in *Great Basin,* Warren L. d'Azevedo (editor), Vol. 11 of *Handbook of North American Indians*, W.C. Sturtevant (general editor), Smithsonian Institution, Washington, D.C.

Smith, M., et al., 2001, "Growth, Decline, Stability and Disruption: A Longitudinal Analysis of Social Well-Being in Four Western Communities," *Rural Sociology* 66:425–450.

Sovell, J.R., and R.P. Guralnick, 2004, *Montane Mollusk and Crustacean Survey of Western Colorado, 2003 Annual Report* from the Colorado Natural Heritage Program and the University of Colorado Museum to the Colorado Division of Wildlife, Denver, Colo. March. Available at http://www.cnhp.colostate.edu/documents/2004/Montane_Mollusk_and_Crustacean_Survey_2004.pdf. Accessed May 16, 2008.

Spahr, N.E., et al., 2000, *Water Quality in the Upper Colorado River Basin, Colorado, 1996–98*, Circular 1214, U.S. Geological Survey.

Standard and Poor's, 2006, *School Matters*. Available at http://www.schoolmatters.com/. Accessed July 2006.

State of Utah, 2006, *Rule R317-6, Ground Water Quality Protection.* Available at http://www.rules.utah.gov/publicat/code/r317/r317-006.htm. Accessed July 6, 2006.

Stehn, T., 2008, *Whooping Crane Recovery Activities November, 2007–September, 2008*. U.S. Fish and Wildlife Service. Available at http://www.whoopingcrane.com/Documents/ WCRA_07to08.pdf. Accessed Sept. 15, 2010.
Strohman, J., 2000, "Surface Water Quality," in *Green River Basin Water Plan Technical Memoranda,* States West Water Resources Corporation. Available at http://waterplan.state. wy.us/plan/green/techmemos/techmemos.html. Accessed May 25, 2006.

Sweetwater County, Wyoming, 2005, *Sweetwater County, Wyoming, Financial and Compliance Report, June 30, 2005*, Sweetwater County Clerk, Green River, Wyo.

SWWRC (States West Water Resources Corporation), 2001a, "Basin Water Use Profile—Agriculture," in *Green River Basin Water Plan Technical Memoranda.* Available at http://waterplan.state.wy.us/ plan/green/techmemos/techmemos.html. Accessed May 25, 2006.

SWWRC, 2001b, *Green River Basin, Water Planning Process*, Feb.

Taba, S.S., et al., 1965, "Notes on the Fishes of the Colorado River near Moab, Utah," *Utah Academy of Science, Arts, and Letters* 42:280–285.

Teuscher, D., and C. Luecke, 1996, "Competition between Kokanees and Utah Chub in Flaming Gorge Reservoir," *Transactions of the American Fisheries Society* 125:505–511.

Tilley, D., et al., 2010, *Plant Guide for Atwood's phacelia* (Phacelia argillacea), USDA-Natural Resources Conservation Service, Idaho Plant Materials Center. Aberdeen, Idaho.

Tipps, B., 1988, *The Tar Sands Project: An Inventory and Predictive Model for Central and Southern Utah*, Cultural Resources Series No. 22, Bureau of Land Management, Utah State Office, Salt Lake City, Utah.

Tobin, R.L., 1987, "Water Quality in the Piceance Basin," pp. 81–85, in *Oil Shale, Water Resources, and Valuable Minerals of the Piceance Basin, Colorado: The Challenge and Choices of Development*, O.J. Taylor (editor), Professional Paper 1310, U.S. Geological Survey.

Tobin, R.L., et al., 1985, *Water-Quality Characteristics of Streams in the Piceance Creek and Yellow Creek Drainage Basins, Northwestern Colorado, Water Years 1977–1981*, U.S. Geological Survey Water-Resources Investigations Report 84-4261.

Toennies, F., 1887, *Gemeinschaft und Gesellschaft*, 1988 translation, Transaction Books, New Brunswick, N.J.

Topper, R., et al., 2003, *Ground Water Atlas of Colorado*, Special Publication 53, Colorado Geological Survey, Denver, Colo.

Town of Meeker, Colorado, 2005, *Town of Meeker, Colorado, Financial Statements and Independent Auditors' Report, December 31, 2005*.

Town of Parachute, Colorado, 2005, *Town of Parachute, Colorado, Financial Statements and Supplemental Information with Independent Auditor's Report, Year Ended December 31, 2005.*

Town of Rangely, Colorado, 2004, *Town of Rangely, Colorado, Financial Statements and Independent Auditors' Report, December 31, 2004*.

Town of Silt, Colorado, 2005, *Town of Silt, Colorado, Financial Statements, December 31, 2005*.

Tyus, H.M., 1987, "Distribution, Reproduction, and Habitat Use of the Razorback Sucker in the Green River, Utah, 1979–1986," *Transactions of the American Fisheries Society* 116:111–116.

Tyus, H.M., 1991, "Ecology and Management of Colorado Squawfish," pp. 379–402, in *Battle against Extinction: Native Fish Management in the American Southwest*, W.L. Minckley and J.E. Deacon (editors), University of Arizona Press, Tucson, Ariz.

Tyus, H.M., 1998, "Early Records of the Endangered Fish *Gila Cypha*, Miller, from the Yampa River of Colorado with Notes on Its Decline," *Copeia* 1998:190–193.

Tyus, H.M., and G.B. Haines, 1991, "Distribution, Habitat Use, and Growth of Age-0 Colorado Squawfish in the Green River Basin, Colorado and Utah," *Transactions of the American Fisheries Society* 120:79–89.

Tyus, H.M., and C.A. Karp, 1990, "Spawning and Movements of the Razorback Sucker, *Xyrauchen texanus*, in the Green River Basin of Colorado and Utah," *Southwestern Naturalist* 35:427–433.

Tyus, H.M., and J.F. Saunders III, 1996, *Nonnative Fishes in Natural Ecosystems and a Strategic Plan for Control of Nonnatives in the Upper Colorado River Basin*, Final Report, Recovery Implementation Program for the Recovery of Endangered Fishes in the Upper Colorado River Basin, U.S. Fish and Wildlife Service, Denver, Colo.

Tyus, H.M., and J.F. Saunders III, 2001, *An Evaluation of the Role of Tributary Streams for Recovery of Endangered Fishes in the Upper Colorado River Basin, with Recommendations for Future Recovery Actions*, Final Report, Project No. 101, prepared for the Upper Colorado Endangered Fish Recovery Program by the Center for Limnology, Cooperative Institute for Research in Environmental Sciences, University of Colorado at Boulder, March.

Tyus, H.M., et al., 1982, "Fishes of the Upper Colorado River Basin: Distribution, Abundance and Status," pp. 12–70, in *Fishes of the Upper Colorado River System: Present and Future*, W.H. Miller et al. (editors), Western Division, American Fisheries Society, Bethesda, Md.

UDEQ (Utah Department of Environmental Quality), 2006, *Water Quality [Uinta Basin]*. Available at http://www.waterquality.utah.gov/watersheds/uinta/water_quality.htm. Accessed May 8, 2006.

UDEQ, 2007, "303(d) List of Impaired Waters," Vol. II in *Utah's 2006 Integrated Report.* Available at http://www.waterquality.utah.gov/documents/200_303d_submittal_3-31-06.pdf. Accessed Sept. 17, 2007.

UDEQ, 2010, *2011 Air Monitoring Network Plan*. Available at http://www.airmonitoring.utah.gov/network/2011AirMonitoringNetworkPlan.PDF. Accessed Oct. 12, 2011.

UDEQ, 2011, *Air Quality Board*. Available at http://www.airquality.utah.gov/Air-Quality-Board/index.htm. Accessed Aug. 23, 2011.

UDNR (Utah Department of Natural Resources), 1999, *Utah State Water Plan—Uinta Basin,* Division of Water Resources.

UDNR, 2000a, *Utah State Water Plan—Southeast Colorado River Basin,* Division of Water Resources.

UDNR, 2000b, *Utah State Water Plan—West Colorado River Basin,* Division of Water Resources.

UDNR, 2001, *Utah's Water Resources, Planning for the Future,* Division of Water Resources.

UDNR, 2006a, *Conservation and Management Plan for Three Fish Species in Utah: Addressing Needs for Roundtail Chub* (Gila robusta), *Bluehead Sucker* (Catostomus discobolus), *and Flannelmouth Sucker* (Catostomus latipinnis), Utah Division of Wildlife Resources, Utah Department of Natural Resources, Salt Lake City, Utah.

UDNR, 2006b, *Range-Wide Conservation Agreement and Strategy for Roundtail Chub* (Gila robusta), *Bluehead Sucker* (Catostomus discobolus), *and Flannelmouth Sucker* (Catostomus latipinnis), Publication No. 06-18, Utah Division of Wildlife Resources, Utah Department of Natural Resources, Salt Lake City, Utah.

UDWR (Utah Division of Wildlife Resources), 2002, *Ute Ladies'-Tresses,* Spiranthes diluvialis, fact sheet.

UDWR, 2006, *Utah Conservation Data Center*, Salt Lake City, Utah. Available at http://dwrcdc.nr.utah.gov/ucdc/. Accessed July 2006.

UDWR, 2008, *Statewide Management Plan for Mule Deer*, Salt Lake City, Utah. Available at http://www.wildlife.utah.gov/hunting/biggame/pdf/mule_deer_plan.pdf. Accessed Sept. 26, 2011.

UDWR, 2009, *Statewide Management Plan for Moose*, Salt Lake City, Utah. Available at http://www/wildlife.utah.gov/hunting/biggame/pdf/moose_plan.pdf. Accessed Sept. 26, 2011.

UDWR, 2010, *Statewide Management Plan for Elk*, Salt Lake City, Utah. Available at http:// wildlife.utah.gov/hunting/biggame/pdf/elk_plan.pdf. Accessed Sept. 26, 2011.

UDWR, 2011a, *Utah Conservation Data Center*, Salt Lake City, Utah. Available at http://dwrcdc.nr.utah.gov/ucdc/default.pdf. Accessed Sept. 14, 2011.

UDWR, 2011b, *Utah Black Bear Management Plan, V. 2.0, 2011-2023*, Available at http://wildlife.utah.gov/bear/pdf/2011_bear_plan.pdf. Accessed Sept. 28, 2011.

UDWR, 2011c, *Utah Conservation Data Center*, Salt Lake City, Utah. Available at http://dwrcdc.nr.utah.gov/ucdc. Accessed Sept. 2011.

Uinta County, Wyoming, 2005, *Uinta County, Wyoming, Comprehensive Annual Financial Report June 30, 2005*, Uinta County Auditor, Evanston, Wyo.

Uintah County, Utah, 2004, *Uintah County Financial Statements for the Year Ended December 31, 2004*.

University of Wyoming, 2006, *Wyoming Natural Diversity Database*. Available at http://uwadmnweb.uwyo.edu/wyndd/. Accessed July 3, 2006.

U.S. Census Bureau, 2007, *American Fact Finder*. Available at http://factfinder.census. gov. Accessed July 2006.

U.S. Census Bureau, 2011a, *County Business Patterns, 2004*, hypertext tables. Available at http://www.census.gov/ftp/pub/epcd/cbp/view/cbpview.html.

U.S. Census Bureau, 2011b, *Federal, State, and Local Governments, Census of Governments*. Available at http://www.census. gov/gov/www/index.html.

U.S. Census Bureau, 2011c, *American FactFinder.* Available at http://factfinder.census. gov.

U.S. Census Bureau, 2011d, *State Interim Population Projections by Age and Sex: 2004–2030*. Available at http://www.census.gov/population/www/projections/projections agesex.html.

U.S. Census Bureau, 2011e, *GCT-T1, Population Estimates*. Available at http://factfinder.census.gov.

U.S. Census Bureau, 2011f, *QT-P32. Income Distribution in 1999 of Households and Families: 2000*. Census 2000 Summary File (SF 3) – Sample Data. Available at http://factfinder.census.gov.

U.S. Census Bureau, 2011g, *S1901, Income in the Past 12 Months, 2006–2008 American Community Survey 3-Year Estimates*. Available at http://factfinder.census.gov.

U.S. Census Bureau, 2011h, *T1, Population Estimates*. Available at http://factfinder.census.gov.

USDA (U.S. Department of Agriculture), 2011, *2007 Census of Agriculture: State and County Data*, Volume 1, Geographic Area Series, National Agricultural Statistics Service, Washington, D.C. Available at http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level.asp.

U.S. Department of Commerce, 2011, *State Personal Income*, Bureau of Economic Analysis. Available at http://www.bea.gov/regional/spi/default.cfm?selTable=SA05N&selSeries=NAICS.

U.S. Department of Labor, 2011, *Local Area Unemployment Statistics: States and Selected Areas: Employment Status of the Civilian Noninstitutional Population, 1976 to 2010*, Annual Averages, Bureau of Labor Statistics. Available at http://www.bls.gov/lau/staadata.txt.

USFWS (U.S. Fish and Wildlife Service), 1967, "Endangered Species List," *Federal Register* 32:4001.

USFWS, 1970, "Part 17—Conservation of Endangered Species and Other Fish or Wildlife (First List of Endangered Foreign Fish and Wildlife as Appendix A)," *Federal Register* 35: 8491–8498.

USFWS, 1978, "Determination of Critical Habitat for the Whooping Crane," *Federal Register* 43:20938–20942.

USFWS, 1982a, *Clay Phacelia Recovery Plan Action Status*, Utah Ecological Services Field Office.

USFWS, 1982b, *Kendall Warm Springs Dace Recovery Plan*, Region 6, Denver, Colo.

USFWS, 1990a, *Humpback Chub Recovery Plan,* Region 6, Denver, Colo.

USFWS, 1990b, *Uinta Basin Hookless Cactus* (Sclerocactus glaucus) *Recovery Plan*, Region 6, Denver, Colo.

USFWS, 1991a, *Autumn Buttercup,* Ranunculus acriformis *var.* aestevalis *Recovery Plan,* Region 6, Denver, Colo.

USFWS, 1991b, *Utah Prairie Dog Recovery Plan*, Region 6, Denver, Colo.

USFWS, 1992, "Final Rule to List the Plant *Spiranthes diluvialis* (Ute Ladies'-Tresses) as a Threatened Species," *Federal Register* 57:2048–2054.

USFWS, 1993a, *Barneby Ridge-Cress Recovery Plan*, Region 6, Denver, Colo.

USFWS, 1993b, *Dudley Bluffs Bladderpod* (Lesquerella congesta) *and Dudley Bluffs Twinpod* (Physaria obcordata) *Recovery Plan*, Grand Junction, Colo.

USFWS, 1993c, *Last Chance Townsendia Recovery Plan*, Region 6, Denver, Colo.

USFWS, 1994a, *Utah Reed Mustards Recovery Plan*, Region 6, Denver, Colo.

USFWS, 1994b, "Endangered and Threatened Wildlife and Plants; Determination of Critical Habitat for the Colorado River Endangered Fishes: Razorback Sucker, Colorado Squawfish, Humpback Chub, and Bonytail Chub," *Federal Register* 59:13374–13400.

USFWS, 1995a, *Recovery Plan for the Mexican Spotted Owl* (Strix occidentalis lucida), Southwestern Region, Albuquerque, N.M.

USFWS, 1995b, *Utah Pediocactus: San Rafael Cactus* (Pediocactus despainii) *and Winkler Cactus* (Pediocactus winkleri) *Recovery Plan*, Region 6, Denver, Colo.

USFWS, 1997a, "Endangered and Threatened Wildlife and Plants; Final Determination of Critical Habitat for the Southwestern Willow Flycatcher," *Federal Register* 62:39129–39147.

USFWS, 1997b, "Endangered and Threatened Wildlife and Plants; 12-Month Finding for a Petition to List the Contiguous United States Population of the Canada Lynx," *Federal Register* 62:28653–28657.

USFWS, 1997c, "Endangered and Threatened Wildlife and Plants: Final Rule to Designate the Whooping Cranes of the Rocky Mountains as Experimental, Nonessential and to Remove Whooping Crane Critical Habitat Designations from Four Locations," *Federal Register* 62:38932–30939.

USFWS, 1998a, "Endangered and Threatened Wildlife and Plants; Establishment of a Nonessential Experimental Population of Black-Footed Ferrets in Northwestern Colorado and Northeastern Utah," *Federal Register* 63:52823–52841.

USFWS, 1998b, "Endangered and Threatened Wildlife and Plants; Proposal to List the Contiguous United States Distinct Population Segment of the Canada Lynx, Proposed Rule," *Federal Register* 63:36993–37013.

USFWS, 1999, "Endangered and Threatened Wildlife and Plants; Proposed Rule to Remove the Bald Eagle in the Lower 48 States from the List of Endangered and Threatened Wildlife," *Federal Register* 64:36453–36464.

USFWS, 2000a, "Endangered and Threatened Wildlife and Plants; Notice of 90-Day Finding for a Petition to List the Yellow-Billed Cuckoo as Endangered and Commencement of a Status Review," *Federal Register* 65:8104–8107.

USFWS, 2000b, "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Contiguous U.S. Distinct Population Segment of the Canada Lynx and Related Rule," *Federal Register* 65:16052–16086.

USFWS, 2001, "Endangered and Threatened Wildlife and Plants; Twelve Month Finding for a Petition to List the Yellow-Billed Cuckoo *(Coccyzus americanus)* in the Western Continental United States, *Federal Register* 66(143):38611–38626.

USFWS, 2002a, *Bonytail* (Gila elegans) *Recovery Goals: Amendment and Supplement to the Bonytail Chub Recovery Plan,* Region 6, Denver, Colo.

USFWS, 2002b, *Humpback Chub* (Gila cypha) *Recovery Goals: Amendment and Supplement to the Humpback Chub Recovery Plan,* Region 6, Denver, Colo.

USFWS, 2002c, *2001 National Survey of Fishing, Hunting and Wildlife Associated Recreation: State Overview, Preliminary Findings*, June. Available at http://library.fws.gov/Pubs/State_overview01.pdf. Accessed March 2007.

USFWS, 2002d, *Southwestern Willow Flycatcher Recovery Plan*, Albuquerque, N.M.

USFWS, 2006a, *U.S. Fish and Wildlife Service Threatened and Endangered Species System, Life Histories.* Available at http://ecos.fws.gov/docs/life_histories/B002.html. Accessed July 3, 2006.

USFWS, 2006b, *U.S. Fish and Wildlife Service, Pacific Region Hopper Mountain National Wildlife Refuge Complex*, *California Condor.* Available at http://www.fws.gov/hopper mountain/cacondor/. Accessed July 13, 2006.

USFWS, 2006c, *U.S. Fish and Wildlife Service Environmental Conservation Online System, Ridge-Cress, Barneby.* Available at http://ecos.fws.gov/species_profile/servlet/gov.doi.species_profile.servlets.SpeciesProfile?spcode=Q1XV. Accessed July 6, 2006.

USFWS, 2006d, *U.S. Fish and Wildlife Service, Mountain-Prairie Region, Endangered Species Program.* Available at http://mountain-prairie.fws.gov/species/plants/grahamsbeardtongue/index.htm. Accessed July 5, 2006.

USFWS, 2006e, *U.S. Fish and Wildlife Service, Designated Critical Habitat for the Mexican Spotted Owl*. Available at http://www.fws.gov/ifw2es/mso/critical_habitat/critical_habitat.htm. Accessed July 12, 2006.

USFWS, 2006f, *U.S. Fish and Wildlife Service, Mexican Spotted Owl Recovery Program, General Biology and Ecological Relationships*. Available at http://www.fws.gov/ifw2es/mso/Biology.cfm. Accessed July 12, 2006.

USFWS, 2006g, *Threatened and Endangered Species Database, Beardtongue, White River.* Available at http://ecos.fws.gov/species_profile/servlet/gov.doi.species_profile.servlets.SpeciesProfile?spcode=Q2QI. Accessed July 11, 2006.

USFWS, 2006h, *U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form for* Penstemon debilis. Available at http://ecos.fws.gov/docs/candforms_pdf/r6/Q36W_pol.pdf. Accessed Sept. 14, 2007.

USFWS, 2006i, "Endangered and Threatened Wildlife and Plants; Proposed Threatened Status for *Penstemon grahamii* (Graham's beardtongue) with Critical Habitat," *Federal Register* 71:3158–3196.

USFWS, 2007a, *Kendall Warm Springs Dace 5-Year Review: Summary and Evaluation*, Mountain-Prairie Regional Office, Cheyenne, Wyo.

USFWS, 2007b, "Endangered and Threatened Wildlife and Plants: 90-day Finding on a Petition to Reclassify the Utah Prairie Dog from Threatened to Endangered and Initiation of a 5-Year Review," *Federal Register* 72(34):7843–7852.

USFWS, 2007c, "Endangered and Threatened Wildlife and Plants; Removing the Bald Eagle in the Lower 48 States from the List of Endangered and Threatened Wildlife, Final Rule," *Federal Register* 72(130):37345–37372.

USFWS, 2008, "Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to List the Gunnison's Prairie Dog as Threatened or Endangered," *Federal Register* 73(24):6660–6684.

USFWS, 2010a, *Recovery Outline for the Sclerocactus brevispinus (Periette Cactus)*, Region 6, Denver, Colo.

USFWS, 2010b, *Greater Sage-Grouse*, Nevada Fish and Wildlife Office. Available at http://www.fws.gov/nevada/nv_species/sage_grouse.html. Accessed Sept. 28, 2011.

USFWS, 2011, *U.S. Fish and Wildlife Service Environmental Conservation Online System, Pariette cactus*. Available at http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=Q3KI. Accessed Sept. 27, 2011.

USGCRP (U.S. Global Change Research Program), 2009, *Global Climate Change Impacts in the United States*, T.R. Karl, J.M. Melillo, and T.C. Peterson (editors), Cambridge University Press. Available at http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf. Accessed July 5, 2011.

USGS (U.S. Geological Survey), 1968, *Mineral and Water Resources of Colorado*, report of the USGS in collaboration with the Colorado Mining Industrial Development Board, Washington, D.C., Oct.

USGS, 1980a, *Raven Ridge–Rim Rock and Vicinity, Utah Tar Sand Leasing Minutes No. 8*, minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980b, *Argyle Canyon–Willow Creek, Utah Tar Sand Leasing Minutes No. 9*, minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980c, *Hill Creek, Utah Tar Sand Leasing Minutes No. 6*, minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 1980d, *P.R. Spring, Utah Tar Sand Leasing Minutes*, minutes of the Mineral Land Evaluation Committee, Sept. 23.

USGS, 1980e, *San Rafael Swell, Utah Tar Sand Leasing Minutes No. 7*, minutes of the Mineral Land Evaluation Committee, Nov. 10.

USGS, 2006a, *USGS 09302000 Duchesne River near Randlett, Utah*. Available at http://waterdata.usgs.gov/usa/nwis/uv?site_no=09302000. Accessed May 8, 2006.

USGS, 2006b, *Water Data for USGS 09328500 San Rafael River near Green River, Utah*. Available at http://waterdata.usgs.gov/usa/nwis/uv?site_no=09328500. Accessed May 8, 2006.

USGS, 2006c, *Water Data for USGS 09333500 Dirty Devil River near Hanksville, Utah*. Available at http://waterdata.usgs.gov/usa/nwis/uv?site_no=09333500. Accessed May 8, 2006.

USGS, 2011, *Water Use in Utah, 2000*, Utah Water Science Center. Available at http://ut.water.usgs.gov/infodata/wateruse.html. Accessed Dec. 14, 2011.

U.S. President, 1994, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," Executive Order 12898, *Federal Register* 59:7629, Feb. 11.

Utah Birds, 2007a, *Bird List for Duchesne County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/DuchesneCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2007b, *Bird List for San Juan County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/SanJuanCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2007c, *Bird List for Uintah County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/UintahCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2007d, *Bird List for Utah County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/UtahCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2007e, *Bird List for Wasatch County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/WasatchCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2010, *Bird List for Garfield County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/GarfieldCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2011a, *Bird List for Carbon County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/CarbonCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2011b, *Bird List for Emery County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/EmeryCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2011c, *Bird List for Grand County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/GrandCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2011d, *Bird List for Wayne County, Utah*, Available at http://www.utahbirds.org/counties/xChecklists/WayneCoCheclist.pdf. Accessed Sept. 26, 2011.

Utah Birds, 2011e, *Taxonomic List of Utah Birds*, Available at http://www.utahbirds.org/birdsofutah/index.html. Accessed Sept. 26, 2011.

Utah Department of Public Safety, 2006, *Crime in Utah: Preliminary Report, 2005*. Available at http://bci.utah.gov/Stats/2005p.pdf. Accessed July 2006.

Utah DNR (Utah Department of Natural Resources), 2000, *Municipal and Industrial Water Supply and Uses in the Uintah Basin (Data Collected for Calendar Year 1995)*, prepared by Division of Waters, July 1998, revised Dec. 2000.

Utah Governor's Office of Planning and Budget, 2006, *Population Projections by County and District*. Available at http://www.governor.utah.gov/DEA/Projections/06ProjCountyand District.pdf. Accessed July 2006.

Utah State Legislature, 2000, *State Park Funding Options*, June. Available at http://www.le.state.ut.us/lfa/reports/ParksFunding.pdf.

Utah State Parks and Recreation, 2006, *State of Utah Natural Resources*, home page. Available at http://www.stateparks.utah.gov/index.php. Accessed Oct. 7, 2011.

Valdez, R.A., 1990, *The Endangered Fish of Cataract Canyon*, final report, prepared by BIO/WEST, Inc., for U.S. Bureau of Reclamation, Salt Lake City, Utah.

Valdez, R.A., and W.J. Masslich, 1989, *Winter Habitat Study of Endangered Fish—Green River: Wintertime Movement and Habitat of Adult Colorado Squawfish and Razorback Suckers*, BIO-WEST, Inc., Logan, Utah.

Valdez, R.A., et al., 1982, "Upper Colorado River Investigation (Rifle, Colorado, to Lake Powell, Utah)," in *Colorado River Fishery Project Final Report*, Field Investigations Report 2, U.S. Fish and Wildlife Service, Salt Lake City, Utah.

Valdez, R.A., et al., 1992, *Characterization of the Life History and Ecology of the Humpback Chub in the Grand Canyon,* Annual Report TR 250-05, BIO-WEST, Inc., Logan, Utah.

Vanden Berg, M.D., 2005, *Reasonably Foreseeable Development Scenario (RFD) for Oil and Gas, RFD for the Monticello Planning Area*, prepared for the Bureau of Land Management, Monticello Field Office, July.

Vanicek, C.D., and R.H. Kramer, 1969, "Life History of the Colorado Squawfish, *Ptychocheilus lucius*, and the Colorado chub, *Gila robusta*, in the Green River in Dinosaur National Monument 1964–1966," *Transactions of the American Fisheries Society* 98:193–208.

Vernal City Corporation, Utah, 2005, *Vernal City Corporation Financial Statements for the Year Ended June 30, 2005*.

Walsh, R.G., et al., 1984, "Valuing Option, Existence and Bequest Demand for Wilderness Land Economics," *Land Economics* 60:14–29.

Ward, J., and T. Naumann, 1998, *Ute Ladies'-Tresses Orchid* (Spiranthes diluvialis Sheviak) *Inventory, Dinosaur National Monument and Browns Park National Wildlife Refuge*, Dinosaur National Monument, National Park Service.

Wayne County, Utah, 2004, *Wayne County Financial Statements, December 31, 2004*.

WDEQ (Wyoming Department of Environmental Quality), 2005, "Water Quality Rules and Regulations," in *Quality Standards for Wyoming Groundwaters*, adopted March 16. Available at http://deq.state.wy.us/wqd/WQDrules/Chapter_08.pdf. Accessed June 6, 2006.

WDEQ, 2006, *Wyoming's 2006 305(b) State Water Quality Assessment Report and 303(d) List of Waters Requiring TMDLs*. Available at http://deq.state.wy.us/wqd/watershed/Downloads/305b/2006/2006_305b_.pdf. Accessed Nov. 13, 2007.

WDEQ, 2011, "Ambient Standards," Chapter 2 in *Wyoming Department of Environmental Quality, Air Quality Division, Standards and Regulations*. Available at http://deq.state.wy.us/aqd/stnd/Chapter2_10-21-09FINAL_CLEAN.pdf. Accessed Aug. 22, 2011.

Weber, W., 1987, *Colorado Flora: Western Slope*, Colorado Associated University Press, Boulder, Colo.

Weeks, J.B., et al., 1974, *Simulated Effects of Oil-Shale Development on the Hydrology of Piceance Basin, Colorado*, U.S. Geological Survey Professional Paper 908.

Weisz, R., 1979, "Stress and Mental Health in a Boom Town," pp. 31–47, in *BoomTowns and Human Services,* J. Davenport and J. Davenport (editors), University of Wyoming Press, Laramie, Wyo.

Welsh, S., and K. Thorne, 1979, *Illustrated Manual of Proposed Endangered and Threatened Plants of Utah*, prepared for U.S. Fish and Wildlife Service, Bureau of Land Management, and U.S. Forest Service.

WGFD (Wyoming Game and Fish Department), 2006, *Wyoming Game and Fish Department, Green River Region, Angler Newsletter*, Green River, Wyo., spring. Available at http://gf.state.wy.us/downloads/pdf/Fish/Newsletters/GreenRiver/2006GRNewsletter.pdf.

WGFD, 2009, *The Official State List of the Common and Scientific Names of the Birds, Mammals, Amphibians, and Reptiles in Wyoming*. Available at http://gf.state.wy.us/wildlife/nongame/Species:ist/2009%20/204-1%20WY%20Species%20List.pdf. Accessed Sept. 26, 2011.

WGFD, 2010a, *Wyoming's State Wildlife Action Plan.* Available at http://gf.state.wy.us/downloads/pdf/swap/2010_SWAP_Complete.pdf. Accessed Aug. 16, 2011.

WGFD, 2010b, *Wyoming Game and Fish Species Accounts*, Cheyenne, Wyo. Available at http://gf.state.wy.us/downloads/pdf/SWAP/Fish/KendallWarmSpringsDace.pdf. Accessed Sept. 28, 2011.

Whitehead, P.G., et al., 2009, "A Review of the Potential Impacts of Climate Change on Surface Water Quality," *Hydrological Sciences Journal* 54:101–123.

Whooping Crane Conservation Association, 2006, *Current Whooping Crane Flock Status (updated on May 5, 2006).* Available at http://www.whoopingcrane.com/FLOCKSTATUS.HTM. Accessed July 13, 2006.

Wilkinson, K.P., 1983, "Divorce and Recent Net Migration into the Old West," *Journal of Marriage and the Family* 45:437–445.

Wilkinson, K.P., and M. Camasso, 1984, "Juvenile Delinquency and Energy Development in a Traditional Setting," unpublished manuscript, Department of Rural Sociology, Pennsylvania State University, State College, Pa.

Wilkinson, K.P., et al., 1982, "Local Social Disruption and Western Energy Development: A Critical Review," *Pacific Sociological Review* 25:275–296.

Wilkinson, K.P., et al., 1984, "Violent Crime in the Western Energy-Development Region," *Sociological Perspectives* 27:241–256.

Williams, M.H., 2002, *Utah's Scenic San Rafael Introduction*. Available at http://www.arapeenatvjam.org/san_rafael_swell.htm. Accessed June 1, 2006.

Wilson, D.M., et al, 1995, "Declining Populations of the Fingernail Clam *Musculium transversum* in the Upper Mississippi River," *Hydrobiologia* 304:209–220.

Woodling, J., 1985, *Colorado's Little Fish: A Guide to the Minnows and Other Lesser Known Fishes in the State of Colorado*, Colorado Division of Wildlife, Department of Natural Resources, Denver, Colo.

Woods, A.J., et al., 2001, *Ecoregions of Utah*, U.S. Geological Survey, Reston, Va.

WRAP (Western Regional Air Partnership), 2006, *Emissions Data Management System (EDMS)*. Available at http://www.wrapedms.org/default_login.asp. Accessed June 2006.

WRCC (Western Regional Climate Center), 2011, *Western U.S. Climate Historical Summaries*. Available at http://www.wrcc.dri.edu/Climsum.html. Accessed Aug. 24, 2011.

Wu, S.-K., and N. Brandauer, 1978, "The Freshwater Mussels (*Family Unionidae*)," *Natural History Inventory of Colorado* 2:41–60, University of Colorado Museum, Boulder, Colo.

Wyoming Department of Administration and Information, 2006, *Population for Wyoming, Counties, Cities, and Towns: 2000 to 2020*. Available at http://eadiv.state.wy.us/pop/wyc&sc20.htm. Accessed March 2007.

Wyoming Division of Criminal Investigation, 2006, *2005 Annual Report: Crime in Wyoming*. Available at http://attorneygeneral.state.wy.us/dci/pdf/2005%20Annual%20Published.pdf. Accessed July 2006.

Wyoming Division of State Parks and Historic Sites, 2006, home page. Available at http://wyoparks.state.wy.us.

Wyoming Governor's Office, 2011, "Greater Sage-Grouse Core Area Protection," State of Wyoming, Executive Department, Executive Order 2011-5, June 2.

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